RFP-ENV-75

MAY 17, 1976

ANNUAL ENVIRONMENTAL MONITORING REPORT

JANUARY – DECEMBER 1975

Rockwell International

Atomics International Division
Rocky Flats Plant

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION CONTRACT E(29-2) - 3533

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SW-A-004778

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Printed in the United States of America
Available from the
National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22161
Price: Printed Copy $4.00 Microfiche $2.25

Printed
May 17, 1976

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Rocky Flats Plant

January through December 1975

Environmental Sciences and Waste Control

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SUBJECT DESCRIPTORS

Air	Plutonium
Americium	Pulse Height Analysis
Beryllium	Soils
Environmental Standards	Tritium
Gaseous Effluents	Uranium
Liquid Effluents	Water

ROCKWELL INTERNATIONAL
ATOMICS INTERNATIONAL DIVISION
ROCKY FLATS PLANT
P.O. BOX 464
GOLDEN, COLORADO 80401

Prepared under Contract E(29-2)-3533
for the
Albuquerque Operations Office
U. S. Energy Research and Development Administration

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U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Rocky Flats Plant

January through December 1975

Milton A. Thompson and Daryl D. Hornbacher

INTRODUCTION

The Rocky Flats Plant is a Government-owned and contractor-operated facility. It is part of a nationwide research, development, and production complex that is administratively controlled by the Albuquerque Operations Office of the U.S. Energy Research and Development Administration (ERDA). In January 1975, the newly formed ERDA assumed administrative responsibility for the Plant from the U.S. Atomic Energy Commission, which had been dissolved. The prime operating contractor is Rockwell International, Atomics International Division. On July 1, 1975, Rockwell International assumed responsibility for Plant operations from Dow Chemical U.S.A., the Plant's original prime contractor. Construction of the facility began in 1951, and operations commenced in 1952.

The Rocky Flats Plant is located in northern Jefferson County, Colorado, almost equidistant from the cities of Boulder, Golden, and Arvada. The facility is centered approximately 26 kilometers (km) or 16 miles (mi) northwest of downtown Denver at 105° 11′ 30″ west longitude, 39° 53′ 30″ north latitude (see Figure 1*). The site consists of approximately 2,650 hectares (6,500 acres) of federally-owned land. As shown in Figure 2, major Plant structures are located within a security-fenced area of 155 hectares (385 acres).

The Plant is a key ERDA facility for producing components for nuclear weapons. Most of the work is directly related to national defense. The Plant is involved in processing plutonium and in fabricating components from uranium, beryllium, and stainless steel. Production activities include numerous metal working, fabrication, and assembly shops, chemical recovery and purification processes, and associated quality control functions. Research efforts include areas of chemistry, physics, materials technology, ecology, nuclear safety, mechanical engineering, health physics, and environmental control.

Currently there are more than 157,900 square meters of floor space in over 90 structures. Of this total, fabrication and assembly facilities account for 41% of the floor space; laboratories and test facilities occupy 15%; administration, personnel, and security account for 9%; utility and support services, including radioactive and nonradioactive waste treatment facilities, occupy 19% of the floor space; warehouse and storage areas account for 9%; and permanent facilities for on-site contractors occupy 2% of the available floor space.

All of the Plant's heating requirements are met by in-plant steam boilers that normally burn natural gas but are capable of converting to fuel oil. During 1975, approximately 750 million cubic feet of natural gas was used to meet the Plant's heating requirements. Water is obtained from the Denver Water Board and is drawn from the Ralston Reservoir and the South Boulder Diversion Canal. The Rocky Flats Plant used 126 million gallons of water during 1975.

*Figures appear at the end of this report.

All process wastewater is analyzed and, if required, radioactive and nonradioactive contaminants are removed prior to the wastewater being stored in evaporation and retention ponds located on the Plant site. Sanitary wastewater is treated by an on-site tertiary treatment facility, one of only two tertiary treatment facilities in Colorado.

The natural environment of the Plant site and vicinity is influenced primarily by two things: (1) the Front Range of the Rocky Mountains, which is immediately west of the site, and (2) the site elevation, which is approximately 1,829 meters (6,000 feet) above sea level. The surficial geology of Rocky Flats consists of a thin layer of gravelly topsoil underlain by a 6- to 15-meter-thick layer (20 to 49 feet) of coarser, clayey gravel. This in turn is underlain by an impermeable bedrock structure upon which most of the building foundations are supported. Area hydrology is controlled by the topsoil, which consists of gravelly and highly permeable alluvium. Little water is retained in the soil, and vegetation in the area is sparse. Assorted low-growing prairie grasses, prickly pear, and spanish bayonet cactus constitute the main ground cover. Cottonwood trees grow adjacent to watercourses.

As shown in Figure 3, surface water runoff from the Plant is from west to east. Runoff is carried from the Plant boundaries by three major drainage basins that are tributary to Walnut Creek on the north and to Woman Creek on the south. The south fork of Walnut Creek is the main effluent watercourse from the Plant. The confluence of the north and south forks of Walnut Creek is 1.1 kilometer (0.7 miles) west of the Plant's eastern boundary. Great Western Reservoir, a major water supply for the City of Broomfield, is about 1.6 km (1 mi) east of this confluence. Woman Creek flows east from Rocky Flats into Standley Lake, a water supply for the City of Westminster and for portions of the cities of Northglenn and Thornton. The north fork of Walnut Creek, south fork of Walnut Creek, and Woman Creek watercourses are designated A, B, and C, respectively.

Personnel in the Environmental Sciences and Waste Control Department of Rockwell International at Rocky Flats conduct a comprehensive environmental monitoring and sampling program. The objective is to determine if Plant operations cause an adverse effect on the environs. The program is designed to provide assurance that the many safeguards in use are working properly. Also involved is assurance that concentrations of released materials are as low as practicable and are within limits set by appropriate regulatory agencies.

The environs are monitored and sampled for radioactivity and for chemical and biological pollutants. Air, water, and soil are sampled not only on the plant site but also in the surrounding region. Several Federal, State, and local governmental agencies conduct additional, independent, environmental surveys on and off the Plant site. The Colorado Department of Health samples air, soil, and water around the Rocky Flats site as a part of the Department's statewide surveillance program. The Jefferson County Health Department performs monthly sewage plant effluent sampling and analysis and has one continuous particulate air sampler on-site that is operated by the Colorado Department of Health. During 1975, the Jefferson County Health Department also conducted a soil sampling study in the vicinity of the Rocky Flats Plant. The Health and Safety Laboratory, which is an ERDA facility based in New York, conducts particulate air sampling in the vicinity of the Rocky Flats Plant and periodically performs soil sampling and analysis. Additional monitoring or sampling is performed periodically by the U.S. Environmental Protection Agency (EPA).

The information contained in this report is a compilation of data provided monthly to the Rocky Flats Area Office of ERDA, the Division of Occupational and Radiological Health of the Colorado Department of Health, the Regional Office of the EPA, the Health Departments of Boulder and Jefferson Counties, and to city officials in several communities near the Plant.

SITE CLIMATOLOGY

Annual precipitation recorded at the site during 1975 was 31.0 centimeters (cm) or 12.2 inches (in.). For the 23-year period, 1952 through 1975,

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the average annual rainfall was 39.6 cm (15.6 in.). The extreme temperatures recorded during 1975 were 33 and −19 °C (91 and −2 °F) with an annual mean temperature of 10 °C (50 °F). The mean wind velocity was 4.2 meters per second (m/s) or 9.4 miles per hour (mph), with a peak gust of 43.4 m/s (97.1 mph) on December 1, 1975.

Hourly observations during 1975 showed that the predominant wind direction was from the northwest. This direction accounted for 22% of the wind observations. A 1975 wind rose is shown in Figure 4.

Loren W. Crow, certified consulting meteorologist from Denver, Colorado, summarized hourly wind data from January 1972 through August 1974 into stability categories and annual frequencies. The following summary remarks, which are excerpted from his report,[1]* are subject to further refinement as additional data become available. During 1975, no stability category work was conducted. The work is being resumed during 1976.

Crow stated in his report that "Neutral stability conditions with corresponding well-mixed airflow prevails slightly over 50 percent of the hours per year at both Rocky Flats and Denver Airport (Stapleton International Airport). Under such conditions there is a wide range of directions of flow with a slightly higher frequency in the direction range from west-northwest through northeast.

"During stable conditions there is a marked difference in the patterns of airflow emanating from the Denver metropolitan area and the airflow emanating from Rocky Flats. The confluence of drainage air from both areas generally occurs above the lower part of the Platte River Valley to the west and north of Brighton, Colorado. There is very little vertical mixing during stable air periods. Stable conditions prevail for 35 and 40 percent of all hours.

"The least frequent stability class is unstable conditions. Most of the unstable hours occur in the summer time when there is strong vertical mixing produced by high surface temperatures during daylight hours. The unstable hours constitute less than 15 percent of the total hours per year. Unstable conditions generally occur when air is moving toward the mountains and with corresponding rapid vertical mixing.

"Repeatable patterns of airflow can be identified in five separately defined categories. Days which are primarily controlled by synoptic airflow and turn-around days are the most frequent types. Almost all dense pollution occurs on turn-around type days in the Denver metropolitan area. The effluents which moved away from either Rocky Flats or the Denver metropolitan area under downslope stable conditions seldom move back over the same source point with more than a small fraction of the initial density. This is particularly true at Rocky Flats where effluents emanate from essentially a point source.

"High wind speeds ≥20 mph (32 km per hour) occur between 500 and 600 hours per year at Rocky Flats. The dominant direction of airflow for such winds is from the west or northwest. Such strong winds are capable of picking up and re-transporting dust particles which have previously obtained some collected burden of pollutant material from a localized source. Densities of gaseous pollutant material or the very small and slowly falling particles containing toxic pollutants would be very low under such strong wind conditions at distances of more than a few hundred yards.

"Under *STABLE* conditions there is a notable difference in airflow between Denver Airport and Rocky Flats. There is a prominent peak frequency of airflow from south-southwest at Denver. By contrast, the range of wind direction under *STABLE* conditions at Rocky Flats carries a broad level of nearly equal frequency from southwest through northwest. In most instances the *STABLE* air temperature near the ground above the lower portions of the Platte River Valley near the north end of Denver is colder during the morning hours than at Rocky Flats. *STABLE* but relatively warmer air moving past Rocky Flats would establish its own equivalent level of buoyancy and move toward the Platte River at a

*Superscript numbers represent correspondingly numbered references listed after the text in this report.

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higher elevation than the colder air near the surface in the Denver metropolitan area. In other instances, *NEUTRAL* stability conditions with corresponding rapid dispersal of effluents will prevail at Rocky Flats while colder *STABLE* air and its collected burden of pollutants will remain near the ground to the north of Denver. Under such circumstances there would be no mixing downward of effluents from Rocky Flats into the *STABLE* air below.

"Under *NEUTRAL* and *UNSTABLE* conditions the frequency distribution of directions is somewhat similar at both locations. However, Rocky Flats has a greater frequency of *UNSTABLE* air motion ranging from the northeast through south-southeast directions. The relatively low frequency of *UNSTABLE* conditions with corresponding rapid vertical mixing should limit any surface deposition of material emanating from Rocky Flats to the first one to three miles (1.6 to 4.8 km) from the source toward higher ground to the west of the plant."

SUMMARY

During 1975, the Rocky Flats Plant conducted a comprehensive environmental monitoring program that included the sampling and analysis of air, water, and soil on and off the plant site. Measurements of environmental penetrating-radiation dose were made using thermoluminescent dosimeters. In addition, an aerial radiological survey was made.

Particulate air samples were collected from air samplers that operated continuously* in 11 communities. Plutonium analyses of these samples produced results indicating that airborne plutonium in communities surrounding the Plant was well within ERDA-established radioactivity concentration guides (RCG). The activity observed was within the range of concentrations attributed to worldwide fallout from nuclear weapons testing.

Plutonium, uranium, americium, and tritium concentrations were monitored in South Walnut Creek (Pond B-4 monitoring station), which contains effluents from Rocky Flats' sanitary waste treatment plant. Similar monitoring occurred at Ponds A-3 and C-1 monitoring stations in the other two watercourses that provide surface drainage from the Plant site. All effluents were determined to be less than 0.16% of applicable RCG.

Tritium concentration in Great Western Reservoir during 1975 was 0.23% of the applicable RCG. During 1974, the tritium concentration in this reservoir was 0.61% of the guide value. These values show less residual concentrations in 1974 and 1975 compared with the concentration noted in 1973. Tritium was released in Plant effluent during 1973 when a shipment of plutonium was processed that, unknown to Rocky Flats personnel, had been contaminated with tritium by another ERDA facility. Several changes in operating and monitoring procedures were initiated to prevent a similar situation in the future.

In 1975, concentrations of plutonium, uranium, and americium in drinking water from nine communities averaged less than 0.03 percent of the applicable RCG.

During 1975, all sanitary wastes were processed through a tertiary treatment system before discharge from the Plant. All Plant discharges were monitored for compliance with the Plant's NPDES* discharge permit. No violations of the monthly discharge limitations occurred; however, daily limitations were exceeded on nine occasions. These exceptions were not of any health or environmental consequence. They resulted primarily from start-up of a tertiary treatment system and from attempts to improve the operation of that new system. Overall, the monitoring of chemical and biological constituents indicated that the tertiary treatment plant provided effective treatment of the sanitary effluent.

Soil samples are collected annually from locations at distances of 1.6 km (1 mi), 3.2 km (2 mi), and 8.0 km (5 mi) from the Plant site at arcs of 18 degrees. Analysis of 11 soil samples collected during 1975 indicated no measurable change in the plutonium concentration in soil. Analysis of the remaining samples is not complete. The majority of above-background values were found

*In this report, continuous means 24 hours of every day.

*National Pollution Discharge Elimination System—an EPA permit identifying permissible discharge levels of various effluents.

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in the eastern sector of the sampling grid systems. This distribution is related to the prevailing westerly winds that dispersed plutonium from metal drums stored outdoors that leaked plutonium-contaminated oil during the period 1958 to 1968.

During the fall of 1975, an aerial radiological survey of the Rocky Flats Plant and environs was conducted by EG&G, Inc. from Las Vegas, Nevada. Preliminary review of the survey data indicated that the concentrations and relative abundance of radioactive isotopes outside the Plant security fence are consistent with normal terrestrial background concentrations.

An assessment was made of the Plant's contribution during 1975 to public radiation dose. Results showed the maximum individual dose at the Plant perimeter was 0.19 millirem per year, and the maximum individual dose at an occupied location was 0.19 millirem in Broomfield, Colorado. The total population dose for this city was 2.76 man-rem. These values represent 0.038, 0.038, and 0.006% respectively of the appropriate ERDA individual and population dose guides. Total dose to the population living within 80 km (50 mi) was calculated to be 13.1 man-rem. In comparison, background radiation exposure from terrestrial and cosmic sources is approximately 116 millirem per year to the population within 80 km of the Plant. This exposure results in an annual dose of 192,058 man-rem.

MONITORING, DATA COLLECTION, ANALYSIS, AND EVALUATION

Applicable Standards

The U.S. Energy Research and Development Administration has published Radioactivity Concentration Guides (RCG)[2] governing permissible concentrations of radionuclides in air (RCG_a) and water (RCG_w) accessible for intake by occupationally exposed individuals, incidentally exposed individuals, and the population at large. These guides are based on recommendations published by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurement (NCRP). Numerical values of these guides are cited in appropriate tables presented elsewhere in this report.

All radionuclides in Plant effluents and environmental samples are assumed to be soluble for purposes of comparison with appropriate concentration guides. This assumption serves as an additional safeguard since the RCG for soluble radionuclides are more restrictive than those for insoluble radioactive materials.

The Rocky Flats administrative guide value for concentrations of plutonium in airborne effluents is 60×10^{-15} microcuries per milliliter (μCi/ml). This value is ERDA's soluble plutonium concentration guide for an individual in the population at large. Other administrative guide values are as follows: for soluble uranium airborne effluents– 20×10^{-12} μCi/ml; for plutonium in effluent water– 1667×10^{-9} μCi/ml (the ERDA soluble plutonium concentration guide value for a suitable sample of the general population); and the comparable ERDA guide for americium-241 in water is 1330×10^{-9} μCi/ml. The EPA's discharge limitation for beryllium (a nonradioactive material) is 10 grams per stationary source in a 24-hour period.[3] The entire Rocky Flats Plant is considered a single stationary source.

In October 1974, under the NPDES permit program, the EPA issued a water discharge permit[4] to the Rocky Flats Plant. The NPDES permit established effluent concentration limitations for nitrate, total nitrogen, phosphate, 5-day biochemical oxygen demand, fluoride, dissolved oxygen, residual chlorine, total suspended solids, fecal coliform bacteria, total chromium, oil and grease, and pH in the sewage treatment plant discharge. It also established limitations for nitrate and pH in the discharge from Holding Pond A-3 in Walnut Creek. Numerical values of the effluent concentration limitations are cited in the tables that appear near the end of this report.

Background Radioactivity

Although the standards for radioactivity relate to concentrations above background, the measurements given in this report include contributions

from fallout and from radioactive materials naturally found in air, soil, and water on the eastern slope of Colorado's Rocky Mountains. Typical, regional, background values for radioactive materials found in environmental media are listed in Table 1. Most of these regional background values were taken from publications prepared by governmental organizations. The source for each value is listed in the footnotes for Table 1.

Background measurements of environmental penetrating-radiation dose are measured at 39 locations on and around the Rocky Flats Plant site. These measurements are normally made over approximately a three-month period. Dosimeters are placed at 13 locations within the area enclosed by the security fence shown in Figure 2. Dose measurements are also made at 16 locations at 3 to 6 km (2 to 4 mi) from the Plant and in 10 communities located within about 32 km (20 mi) of Rocky Flats.

At each location, two thermoluminescent dosimeters are deployed at a height of 1.8 to 2.4 meters (6 to 8 feet) above ground level. Each dosimeter consists of a sealed glass bulb enclosing two extruded ribbons of CaF_2:Mn that sandwich a central metal heater strip. The dosimeters are enclosed in a case equipped with an energy compensating shield.

Table 2 shows 1975 environmental dose analyses and a comparison of arithmetic and geometric statistics. The geometric mean for the dose values measured on-site, in the environs, and in nearby communities was 107, 103, and 116 millirem respectively. These dose values are statistically indistinguishable and are considered to be typical background values derived from terrestrial and cosmic radiation.

Analytical Procedures

Plutonium, uranium, and americium were determined in the various environmental and effluent samples by radiochemical procedures. Separation from the various sampling matrices and isolation from other radionuclides was accomplished by ion exchange techniques.[5] The purified radioisotopes were electrodeposited onto stainless steel disks and were analyzed by alpha-pulse-height spectrometry.

Variations in such things as counting efficiency, counting time, and chemical yields were compensated for by adding a known quantity of a nonindigenous tracer radioisotope to each sample. This step was conducted prior to chemical separation from the sampling matrix.

Tritium analysis was conducted by liquid scintillation counting techniques. Beryllium analysis was carried out by atomic absorption spectrophotometry.[6]

Detection Limits

Table 3 shows nominal values for the minimum detectable concentrations (MDC) of materials in various media. The values shown are for typical sample volumes as used in the Rocky Flats monitoring program. For any individual sample, the MDC may be greater or smaller, depending on the size of the sample collected and analyzed. Table 3 also lists the various nonradioactive standards and radioactivity concentration guides applicable to airborne and waterborne effluent releases from the Rocky Flats Plant.

Data Reduction

Throughout the data presented, samples with concentrations below the MDC were considered, for averaging purposes, as having the MDC. When one or more MDC values are included in a set of values, the computed mean value of that set is indicated by a "less than" sign (<). The average concentrations (C_{avg}) are represented by pairs of numbers (e.g. 0.01 ±28%) that define the 95 percent confidence interval for C_{avg}. This interval is centered at the arithmetic mean of the observed concentrations ($\bar{c}$). The probability (P) that C_{avg} lies within the stated interval is 95 percent. This may also be expressed as follows:

$$P\left[\left(\bar{c} - t_{0.975}\sqrt{\frac{\sum_{i=1}^{n} c_1^2 - n\bar{c}^2}{n(n-1)}}\right) \leqslant C_{avg} \leqslant \left(\bar{c} + t_{0.975}\sqrt{\frac{\sum_{i=1}^{n} c_1^2 - n\bar{c}^2}{n(n-1)}}\right)\right] = 0.95$$

Where,

$\bar{c}$ = the arithmetic mean of observed concentrations. It is volume weighted whenever the volume is measured

$t_{0.975}$ = value taken from a standard t-test table

n = number of samples

c_1 = an individual, observed concentration

Quality Control

A comprehensive analytical quality control program is conducted in the Rocky Flats Environmental Analysis Laboratory. The primary goals of the program are to improve and document the capability of environmental measurement processes. During 1975, the activities of the analytical quality control program were threefold:

1. Development, updating, and issuance of procedures.
2. Intralaboratory quality control.
3. Interlaboratory quality control.

Intralaboratory quality control has been achieved through routine analysis of "blind" standard samples prepared and issued by the Rocky Flats Chemical Standards Laboratory. Numerical analysis of analytical results from these "blind" samples and subsequent assessment of laboratory performance is performed by the Chemical Standards Laboratory on a monthly basis.

The Environmental Analysis Laboratory also participates in the Interlaboratory Cross Check Program provided by EPA's Environmental Measurements Support Laboratory in Las Vegas, Nevada. The EPA routinely submits environmental type samples containing precisely known amounts of one or more radionuclides to Rocky Flats' Environmental Analysis Laboratory and to other participating laboratories for analysis. The resulting analyses are returned to the EPA for statistical analysis and for comparison to analyses submitted by the other participating laboratories. Computer reports and laboratory performance charts periodically furnished by the EPA indicate that the Rocky Flats Environmental Laboratory performance is satisfactory.

Occasionally, changes such as new sampling media, sampling techniques, and different or special radioisotopes are added to the routine analysis program. These changes are accommodated by proper modification to the quality control program. A summary of the Rocky Flats Environmental Analysis Laboratory performance during 1975 is shown in Table 4.

Airborne Effluent Monitoring

Effluent air from production and research facilities at Rocky Flats is continuously sampled prior to being exhausted to the atmosphere. The filterable particulate effluent samples are collected isokinetically downstream from the final stage of High Efficiency Particulate Air (HEPA) filters. Exhaust air ducts from plutonium facilities have a minimum of two particulate sampling points in addition to an automatic-alarming monitoring system. Three times during each work week, particulate samples are collected from exhaust ducts and stacks that potentially could contain plutonium, uranium, and beryllium. Gelman Type AE® glass fiber filters are used in this sample collection system. Tritium effluents are similarly collected, using a water bubbler impinger, and are

analyzed by liquid scintillation counting. The particulate samples are radiometrically analyzed for total long-lived alpha (TLLa) emitters. Beryllium particulate emissions are determined by the flame atomic absorption spectrophotometry technique. In addition, effluent samples from buildings containing plutonium are composited weekly for specific radiochemical analysis for plutonium.

Table 5 shows the quantity of radioisotopes and beryllium released to the atmosphere from Plant facilities during 1975. During this time period, over 7000 individual analyses were performed. The plutonium release was less than 9.850 microcuries. Total long-lived alpha emission from uranium and research buildings was less than 47.590 microcuries. In addition, less than 1.539 curies of tritium and less than 5.181 grams of beryllium were released to the atmosphere.

Ambient Air Monitoring

High-volume ambient air samplers are located on the Plant site, off-site at a distance of approximately 3 to 6 kilometers (2 to 4 miles) from the Plant center, and in several surrounding communities.

The air samplers are of a Rocky Flats design, and they incorporate a commercially available Rotron Cyclonair blower, Model CHE-3. This blower is mounted in an aluminum box and is equipped with inlet and exhaust mufflers for noise control. The noise level is approximately 45 decibels ("A") at 3 meters (10 feet). This feature makes these samplers ideal for use in residential areas. Also included is a flow meter operated by an annular probe. A resettable elapsed-time indicator is provided. The high-volume sampler operates continuously and draws a volume of air approximating 19 liters per second (40 cubic feet per minute) through a 20- X 25-centimeter (8- X 10-inch) Delbag Microsorban® filter. These new samplers are replacing units that operated at 0.96 liters per second (2 cubic feet per minute).

Ambient air is sampled continuously at 24 locations within and on the perimeter of the Rocky Flats security area. These locations are shown in Figure 5. The sample filters are collected weekly, composited by location, and analyzed monthly for plutonium, total long-lived beta emitting radionuclides, and beryllium. Table 6 shows the volume-weighted average concentrations of plutonium in airborne particulates during 1975. Results from Air Sampler S-6 showed the highest percent of RCG_a during the year. That sampler is located at the perimeter security fence and is directly east of a sludge drying bed that contains some residual plutonium contamination. Next highest in percent of RCG_a were results from Air Samplers S-7, S-8, and S-9, which are located directly east of an area previously used for oil drum storage. Plutonium-contaminated oil leaked from drums stored in this area during the period 1958 to 1968. These four sampler locations experienced the greatest concentrations of airborne plutonium activity. The plutonium concentration at Samplers S-6 through S-9 was less than 1.63% of the applicable RCG_a. The average concentration of plutonium in ambient air at all on-site stations during 1975 was less than 0.198 $\pm 39\% \times 10^{-15}$ μCi/ml. This concentration was less than 0.33 percent of the RCG_a for soluble plutonium in ambient air accessible to incidentally exposed individuals.

Routine analysis for beta-emitting particulates began in December 1975. The volume-weighted average concentrations of long-lived, beta emitting radionuclides for the month of December are shown in Table 7. The average concentration of long-lived beta emitters at Ambient Air Monitoring Stations S-1 through S-24 during December was $0.0406 \pm 7\% \times 10^{-12}$ μCi/ml. This concentration was 0.04 percent of the RCG_a for total long-lived beta activity in ambient air accessible to incidentally exposed individuals.

Airborne particulate samples are collected by high-volume air samplers at 14 locations surrounding the Rocky Flats Plant and are located between 3 to 6 kilometers (2 to 4 miles) from the Plant center (Figure 6). The samplers are numbered S-31 through S-44. Samples from each location are collected weekly, composited by location, and analyzed monthly for plutonium. Table 8 shows the volume-weighted average concentrations of plutonium in airborne particulates at Samplers

S-31 through S-44 during 1975. The average concentration of plutonium in ambient air at these locations during 1975 was less than $0.037 \pm 29\% \times 10^{-15}$ μCi/ml. This concentration was less than 0.19 percent of the soluble plutonium RCG_a for the general population.

Airborne particulate samples are collected by high volume air samplers at 11 locations in or near communities in the vicinity of the Rocky Flats Plant. These locations, shown in Figure 6, include Boulder, Broomfield, Denver, Golden, Lafayette, Leyden, Marshall, Superior, Wagner, Walnut Creek, and Westminster. Samples are collected weekly, composited by location, and analyzed monthly for plutonium and total long-lived beta emitting radionuclides.

Table 9 shows the volume-weighted concentrations of plutonium in airborne particulates at the community stations during 1975. The average concentration of plutonium in ambient air at the community stations was less than $0.031 \pm 20\% \times 10^{-15}$ μCi/ml. That concentration was less than 0.16 percent of the soluble plutonium RCG_a for the general population.

The volume-weighted concentrations of long-lived beta emitting radionuclides for the month of December 1975 are given in Table 10. The average concentration of long-lived beta emitters in the communities during December was $0.024 \pm 18\% \times 10^{-12}$ μCi/ml. This concentration was 0.02 percent of the total long-lived beta activity RCG_a for the general population.

Waterborne Effluent Monitoring

During 1975, wastewater discharged from the Rocky Flats Plant consisted of filter backwash from the water-treatment plant, treated sanitary waste, cooling-tower blowdown, and steam condensate. Discharge of filter backwash from the water-treatment plant was discontinued in June 1975 in compliance with EPA's NPDES discharge permit for the Rocky Flats Plant.

A tertiary treatment system for processing sanitary wastes was completed in December 1974. During 1975, all sanitary wastes were subjected to tertiary treatment before discharge from the Plant. Solids resulting from this operation are decomposed in an anaerobic digestor. After drying, the contents of the digestor are packaged in 55-gallon drums and are shipped to an ERDA waste-storage facility in Idaho.

Treated, liquid, sanitary effluents are discharged to the B-series holding ponds via South Walnut Creek (see Figure 3). Holding Ponds B-1, B-3, and B-4 provide additional natural treatment of water discharged from the sanitary waste treatment facility prior to that water's release off-site. Ponds B-1 and B-3 are equipped to impound water so that analysis can be performed prior to release and to prevent accidental liquid releases. Pond B-2 is isolated from the stream and is used to impound process wastewater. The process wastewater is then pumped to Pond A-2 on North Walnut Creek for storage and evaporation.

Average concentrations of chemical and biological parameters of routine liquid effluent samples collected during 1975 are shown in Table 11. This table is divided into sections that list the appropriate Colorado Department of Health standards and EPA-NPDES permit limitations in effect during 1975. Daily NPDES effluent concentrations were exceeded at the sewage-treatment plant outfall on nine occasions. Table 12 lists these minor violations and indicates the probable causes. Seven of the violations occurred in January. Six of those seven were directly related to a project in which an attempt was made (through the addition of methyl alcohol) to denitrify the sanitary effluent by bacterial action. Overall, the tertiary treatment system operated successfully during the year.

North Walnut Creek receives natural runoff from the north side of the Plant site. Holding Ponds A-1 and A-3 on North Walnut Creek are used to impound surface water runoff for analysis prior to that water being released. Pond A-2 is isolated from the stream and is used to store process wastewater. One holding pond, C-1, is located on Woman Creek and can be used to impound accidental releases of liquid. No impoundment of effluent waters on any of the three watercourses was necessary during 1975.

When planned releases are made from Holding Pond A-3, the water is sampled continuously. These samples are analyzed for plutonium, uranium, and americium. Water is sampled continuously and collected daily from the outfalls of Ponds B-4 and C-1 (Figure 3). These daily samples are composited into weekly samples for analysis of plutonium, uranium, and americium. Plutonium and uranium are isolated from other long-lived alpha emitters by ion exchange chromatography,[5] and their concentrations are determined by alpha pulse-height spectrometry. The chemical recovery of plutonium for the analytical procedure is determined by adding a plutonium-236 tracer. Uranium and americium recovery is determined by uranium-232 and curium-244 tracers respectively.

Concentrations of plutonium, uranium, and americium in water sampled at the outfalls of Ponds A-3, B-4, and C-1 are shown in Table 13. The annual average concentrations of plutonium in the outfalls of these ponds during 1975 were

A-3 = $<0.285 \pm 41\% \times 10^{-9}$ μCi/ml ($<0.02\%$ of the RCG_W)

B-4 = $2.635 \pm 8\% \times 10^{-9}$ μCi/ml (0.16% of the RCG_W)

and

C-1 = $<0.235 \pm 68\% \times 10^{-9}$ μCi/ml ($<0.01\%$ of the RCG_W)

All uranium and americium concentrations in these ponds were less than 0.09% of the applicable RCG_W.

Walnut Creek is sampled continuously at Indiana Street, downstream from the confluence of the stream tributaries and approximately at the Plant's east boundary. These samples are composited weekly and analyzed for plutonium, uranium, and americium. Results of the analyses are shown in Table 14. The 1975 average concentrations of plutonium, uranium, and americium at the Indiana Street location were respectively

$0.648 \pm 23\% \times 10^{-9}$ μCi/ml (0.04% of the RCG_W),

$2.844 \pm 13\% \times 10^{-9}$ μCi/ml (0.03% of the RCG_W),

and

$0.181 \pm 30\% \times 10^{-9}$ μCi/ml (0.01% of the RCG_W).

Tritium

Tritium was released in Plant effluent water during 1973, 1974, and 1975. This resulted from processing a shipment of plutonium during 1973 that, unknown to Rocky Flats Plant personnel, had been contaminated with tritium by another ERDA facility. To prevent recurrence of such an incident, more stringent procedures have been established to detect tritium and additional radionuclides in all incoming shipments and in Plant effluents. The tritium-release incident was investigated by the AEC[7] and by the EPA.[8] Findings from both agencies showed that the quantity of tritium released from Rocky Flats presented no hazard to human health.

Water sampled continuously at the outfalls of Ponds B-4, C-1, and at Walnut Creek at Indiana Street was analyzed daily for tritium by liquid scintillation spectrometry. Pond A-3 was sampled and analyzed for tritium during each scheduled discharge. Water samples collected weekly at Great Western Reservoir and Standley Lake also were analyzed for tritium. The average concentrations of tritium in water samples analyzed during 1975 are summarized in Table 15. The tritium concentrations at all of the above locations were less than 0.24% of the applicable RCG_W.

Groundwater Monitoring

The Rocky Flats Plant routinely samples 35 hydrologic test holes at five-month intervals. This test is conducted to determine if there is any movement of chemical or radioactive materials of Plant origin into water-bearing strata underlying the site.

Three of the test holes are approximately 46 meters (150 feet) deep. These test holes provide information concerning water movement in bedrock formations. The remaining test holes range from 6 to 9 meters (20 to 30 feet) deep and are generally

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located near three on-site solar evaporation ponds and downstream from the holding ponds. The locations of all 35 test holes are shown in Figure 7.

During May and October of 1975, test holes containing water were sampled and analyzed for plutonium, uranium, americium, and tritium. Table 16 gives the concentration of radioactive material found in water from each test hole sampled during 1975. The depths of the test holes are included in this table.

Historically the samples indicate no movement of plutonium into the groundwater of the Plant site; however, tritium has appeared in test holes surrounding the solar evaporation ponds. This indicates some seepage of water from these ponds into the surrounding soil.

Regional Water Monitoring

Water samples are collected weekly from Great Western Reservoir, which is a water supply for the City of Broomfield, and from Standley Lake, which supplies the City of Westminster and portions of the Thornton-Northglenn area. Tap or finished water from Broomfield and Westminster is collected weekly. Weekly tap water samples also are collected and individually composited into monthly samples for analysis from the surrounding communities of Arvada, Boulder, Denver, Golden, Lafayette, Louisville, and Thornton. These samples are analyzed specifically for plutonium, uranium, and americium. The resulting data for 1975 are summarized in Table 17.

During 1975, the plutonium concentration in reservoir samples averaged less than 0.099×10^{-9} μCi/ml. Community tap water samples averaged less than 0.027×10^{-9} μCi/ml. These concentrations were less than 0.002% of the soluble plutonium RCG_W for the general population.

In September 1975, single water samples were collected from 25 additional regional lakes, reservoirs, and streams. Samples were collected to a distance of 32 km (20 mi) from the Plant and were analyzed specifically for plutonium, uranium, and americium. The resulting data, presented in Table 18, show that the average plutonium concentration in those samples was $<0.155 \pm 140\% \times 10^{-9}$ μCi/ml. That concentration was less than 0.01% of the soluble plutonium RCG_W for the general population.

Soil Sampling

Approximately 60 soil samples are collected annually in the Plant environs. Samples are collected each 18 degrees of arc on circles having radii of 1.6, 3.2, and 8 kilometers (1, 2, and 5 miles) concentric with the center of the Plant. These samples are analyzed for plutonium. The geometry of all soil samples is carefully controlled by driving a 10- X 10-cm (4- by 4-in.) cutting tool 5 cm (2 in.) into undisturbed soil. The soil sample contained within the tool cavity is then removed for analysis.

Sample preparation and analysis for plutonium is conducted using the method reported by Talvitie.[9] The samples are oven-dried at 120 °C (248 °F), then weighed, sieved through a 10-mesh sieve to remove coarser rubble, and homogenized. Five grams of pulverized soil are used for plutonium analysis. The chemical recovery of plutonium for the analytical procedure is determined by adding a plutonium-236 tracer, and the analytical results are reported from the laboratory in units of disintegrations per minute per gram of dry soil fines. These results are corrected to account for the coarse material removed by sieving. To accomplish this correction, the laboratory result is multiplied by the ratio of grams fines to grams total sample. The corrected result, in units of disintegrations per minute per gram of dry soil, is converted to picocuries per gram of dry soil. No Federal standards for the concentration of plutonium in soil exist.

During the 1975 sampling and analysis program, a sample cross-contamination problem is believed to have occurred. To date, the results from 11 samples have been statistically analyzed and the concentrations verified. These results are displayed on a map in Figure 8. The remaining samples are being reanalyzed and the resulting concentrations will be reported after statistical analysis and verification are performed.

Aerial Radiological Survey

During the fall of 1975, an aerial radiological survey of the Rocky Flats Plant and environs was conducted by EG&G, Inc., Las Vegas, Nevada. The survey was conducted to measure the total terrestrial gamma-radiation exposure rates within the energy ranges of $0.05 \leqslant E\gamma \leqslant 3.0$ MeV and $0 \leqslant E\gamma \leqslant 300$ KeV.

During this survey, a series of lines spaced 61 meters (200 feet) apart were flown directly over the Plant at a height of 46 meters (150 feet). This detailed survey included an area of approximately 42 square kilometers (16 square miles).

A high-sensitivity detection system collected gamma-ray spectral and gross count data. The data then were computer-processed into a map showing isoexposure contours approximately one meter (three feet) above the ground.

Final evaluation and summary of this survey has not been completed; however, a preliminary review of the 1975 data was made. That review plus data from previously conducted aerial surveys indicated that the concentration and relative abundance of radioactive isotopes outside the Plant security fence has not changed and are consistent with normal terrestrial background radiation. Slightly higher-than-background radioactivity was detected at and within the security fence. This activity is associated with buildings where radioactive materials are processed and stored and with an area of known plutonium-contaminated soil, which resulted from leaking oil drums during the period 1958 to 1968.

ASSESSMENT OF PLANT CONTRIBUTION TO PUBLIC RADIATION DOSE

The Rocky Flats Plant has always strived to restrict its radioactive and nonradioactive effluents to concentrations substantially less than the allowable limits. This effort is directed toward minimizing potential hazards such as Plant effluents containing plutonium, uranium, americium, and/or tritium that could contribute to radiation exposure of the general population.

Plutonium does not occur naturally; therefore, the presence of plutonium in the environment can be attributed to either the Rocky Flats Plant or to fallout and resuspension from nuclear testing. Uranium is found naturally and, in many areas of Colorado, is present in much higher concentrations than found locally. Tritium also occurs naturally; however, some tritium in the local environment is the result of Plant operations.

Most of the food consumed locally is produced at considerable distances from the Rocky Flats Plant. Other than from a few family garden plots, the only crops grown locally are wheat and alfalfa. A few cattle also are raised in the Plant vicinity. Since no food sampling data are presently available, no estimates were made concerning the dose received by local residents from the consumption of food products.

In determining the estimated doses from other sources, several conservative assumptions were made. It was assumed that all of the radionuclide was in a chemical form that would result in maximum uptake. To estimate possible damage to the lung, for example, the plutonium was assumed to be completely insoluble; for other body uptake, the soluble form was considered. In each case, the most restrictive conversion from concentration to dose was used.

Potential dose resulting from the off-site release of radioactive liquid and air effluents was calculated at several locations within the Rocky Flats environs. All significant exposure pathways and sources, together with the actual environmental and effluent monitoring data, were considered in making the dose assessment. Table 19 gives the radioactivity concentrations used for the dose calculations. Background radioactivity values were subtracted from these concentrations before the dose assessments were made.

Dose assessments were made for individuals at the specific site-boundary location where maximum exposure rates existed. Doses to individuals and population groups in the Denver metropolitan area were calculated where the highest radioactivity concentrations were measured. An estimate also was made of the total population dose at 80 km (50 mi) from the Plant.

Dose estimates from radionuclides originating in effluents released from the Rocky Flats Plant were obtained using models and data presented in publications of the International Commission on Radiological Protection[10, 11] and other literature.[12] The general equation used in assessing the dose resulting from continuous inhalation or ingestion of a radionuclide was

$$D = \frac{(3.7 \times 10^4)(1.6 \times 10^{-6})(3.15 \times 10^7)(1 - e^{-\lambda_e t}) I_i f_i \epsilon C_i}{100 \lambda_e m}$$

where D = dose resulting from continuous exposure (rem/yr).

3.7×10^4 = dis/sec-μCi

1.6×10^{-6} = ergs/MeV

3.15×10^7 = sec/yr

e = base of natural logarithm

ϵ = effective absorbed energy per disintegration, including a quality factor for dose equivalent, MeV-rem/dis-rad (Ref. 10)

λ_e = effective elimination or clearance rate, day^{-1} (Ref. 10, 11)

t = exposure time

I_i = average air or water intake rate ml/day (Ref. 10)

f_i = fraction of nuclide reaching organ of interest (Ref. 10, 11)

C_i = average nuclide concentration, μCi/ml (as measured)

100 = erg/g-rad

m = organ mass, grams (Ref. 10)

Air and water are considered to be the only significant modes of radionuclide intake. Incorporation of these parameters into the equation results in the dose conversion factors shown in Table 20.

Maximum Site Boundary Exposure Rate

During 1975, the point of maximum potential exposure to an individual on the site boundary was located east of the Plant at Air Sampler Location S-37. If an individual were to continuously occupy this location, using water from Walnut Creek, the exposure in excess of that due to regional background concentrations would be 0.19 mrem per year. This dose represents less than 0.038 percent of the ERDA radiation protection standard for an individual in the population. For purposes of comparison, an annual dose due to terrestrial and cosmic background sources was 113 mrem per year at this unoccupied location.

Maximum Individual and Population Exposures

The maximum individual dose that may be attributed to Plant operations was found to occur in the community of Broomfield, Colorado located about 11 km (6.8 mi) east of Rocky Flats. The principle dose contribution was the result of waterborne tritium, of Plant origin, in excess of regional background concentrations in the water supply.

The annual exposure dose to an individual Broomfield resident is 0.19 mrem; the dose to the entire community population is 2.76 man-rem. This represents 0.038% and 0.11%, respectively, of the individual and population radiation protection standards. This population dose commitment compares to an exposure to the Broomfield population of 1660 man-rem from terrestrial and cosmic background sources.

80-Kilometer Man-Rem Dose

Rocky Flats' routine environmental monitoring of air extends only to a radial distance of about 26 km from the Plant (i.e., downtown Denver). Dispersion calculations were made to determine the dose commitment due to increased plutonium concentrations that, as a result of Plant operations, were present in ambient air beyond 26 km. The emission rates were derived from the effluent releases shown in Table 5. These time-averaged

emissions were applied using a long-term sector averaging Gaussian dispersion model. The model predicts long-term ground level concentrations under conditions of differing meteorology. These model-predicted calculations showed that plutonium concentrations would not exceed regional plutonium-background concentrations at the Plant boundaries.

To assess the population dose in the 80-km sectors adjacent to the Plant, a somewhat conservative assumption was made. It was assumed that the radionuclide concentrations, in excess of background, measured in the surrounding communities are typical of those found to a distance of 80 km. This assumption provides an estimated whole-body population dose of 13.1 man-rem. This dose is 0.005% of the ERDA radiation-protection standard for the general public and compares to a dose of 193,383 man-rem from terrestrial and cosmic background sources.

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TABLES 1 through 20

TABLE 1. Regional Background Radioactivity Concentrations

Radionuclide	Air ($\times 10^{-15}$ µCi/ml)	Soil (pCi/g)[a]	Water ($\times 10^{-9}$ µCi/ml)
Uranium-234, 235, 238	0.0881 ±10.8%[a]	5.68 ± 61.1%[b]	0.274 ± 12.4%[a]
Plutonium-238	0.0031 ±35.5%[a]	0.012 ±116.7%[c]	0.003 ±100%[a]
Plutonium-239, 240	0.0399 ±48.6%[a]	0.014 ± 29.0%[d]	0.012 ± 66.7%[a]
Americium-241	0.0114 ±51.4%[c]	<0.039[c]	0.002 ±250%[e]
Tritium (^{3}H)	2000 ±50%[e]	No Value	460 ±100%[c]

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b. Program 25. U. S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada. August 1973.
c. C. W. Thomas. Personal Communication. Battelle Pacific Northwest Laboratory, Richland, Washington, May 30, 1974.
d. P. W. Krey. *Health Physics* 30:290-214 (1976).
e. Rocky Flats Environmental Analysis Laboratory. 1975.

TABLE 2. 1975 Environmental Dose Analyses

Location	Number of Samples	Annual Dose (millirem)			
		Arithmetic		Geometric	
		Mean	Standard Deviation	Mean	Standard Deviation
On-Site	87	111	20	107	1.18
Environs[a]	97	107	19	103	1.18
Communities	62	115	18	116	1.16

a. 3-6 km (2-4 mi) from the Plant.

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TABLE 3. Radioactive and Nonradioactive Detection Limits and Applicable Standards

Parameter	Approximate Sample Volume	Minimum Detectable Concentration (μCi/ml)		Applicable Standard (μCi/ml)		Reference
Stack Samples						
Plutonium	570.5 m^3	0.00016	$\times 10^{-12}$	$\leq$ 0.06	$\times 10^{-12}$	RF Guide
Total Long-Lived Alpha	570.5 m^3	0.002	$\times 10^{-12}$	$\leq$ 0.02	$\times 10^{-12}$	RF Guide
Total Long-Lived Beta	570.5 m^3	0.030	$\times 10^{-12}$	$\leq$ 100.1	$\times 10^{-12}$	RF Guide
Uranium	570.5 m^3	0.00016	$\times 10^{-12}$	$\leq$ 20.0	$\times 10^{-12}$	RF Guide
Tritium	6.0 m^3	76.7	$\times 10^{-12}$	$\leq$ 2.0	$\times 10^{-7}$	RF Guide
Beryllium	570.5 m^3	0.00001	$\mu g/m^3$	$\leq$ 0.01	$\mu g/m^3$	40 CFR 61
Ambient Air Samples						
Plutonium	2,526.0 m^3	0.00004	$\times 10^{-12}$	$\leq$ 0.02	$\times 10^{-12}$	AECMC 0524
Plutonium	11,410.0 m^3	0.000008	$\times 10^{-12}$	$\leq$ 0.02	$\times 10^{-12}$	AECMC 0524
Total Long-Lived Alpha	570.5 m^3	0.002	$\times 10^{-12}$	$\leq$ 0.007	$\times 10^{-12}$	AECMC 0524
Total Long-Lived Beta	570.5 m^3	0.030	$\times 10^{-12}$	$\leq$ 100.1	$\times 10^{-12}$	AECMC 0524
Tritium	10.0 m^3	2.0	$\times 10^{-12}$	$\leq$ 6.6	$\times 10^{-8}$	AECMC 0524
Beryllium	570.5 m^3	0.00001	$\mu g/m^3$	$\leq$ 0.01	$\mu g/m^3$	40 CFR 61
Beryllium	11,410.0 m^3	0.0000005	$\mu g/m^3$	$\leq$ 0.01	$\mu g/m^3$	40 CFR 61
Effluent Water Samples, Radioactive						
Plutonium	1 liter	0.10	$\times 10^{-9}$	$\leq$ 1,667	$\times 10^{-9}$	AECMC 0524
Uranium	1 liter	0.10	$\times 10^{-9}$	$\leq$ 10,000	$\times 10^{-9}$	AECMC 0524
Americium	1 liter	0.10	$\times 10^{-9}$	$\leq$ 1,330	$\times 10^{-9}$	AECMC 0524
Tritium	1 liter	460.	$\times 10^{-9}$	$\leq$ 1,000,000	$\times 10^{-9}$	AECMC 0524
Total Long-Lived Alpha	25 milliliters	5.0	$\times 10^{-9}$	$\leq$ 40	$\times 10^{-9}$	RF Guide
Soil Samples, Radioactive						
Plutonium	10 grams	0.01	pCi/g	NA		NA
Effluent Water Samples, Nonradioactive						
pH	NA	0 to 14		6.0 to 9.0		NPDES Permit
Total Nitrogen	10 ml	0.2	mg/l	$\leq$ 20	mg/l	NPDES Permit
Phosphorus as P	50 ml	0.2	mg/l	$\leq$ 8	mg/l	NPDES Permit
Fluoride	20 ml	0.2	mg/l	$\leq$ 1.7	mg/l	NPDES Permit
Biochemical Oxygen Demand, 5-Day	10 ml	1.0	mg/l	$\leq$ 25	mg/l	NPDES Permit
Dissolved Oxygen	300 ml	1.0	mg/l	$\geq$ 2	mg/l	NPDES Permit
Total Suspended Solids	100 ml	2.0	mg/l	$\leq$ 25	mg/l	NPDES Permit
Total Chromium	5 ml	0.05	mg/l	$\leq$ 0.1	mg/l	NPDES Permit
Residual Chlorine	10 ml	<0.1	mg/l	$\leq$ 0.1	mg/l	NPDES Permit
Oil and Grease	500 ml	0.1	mg/l	$\leq$ 10	mg/l	NPDES Permit
Fecal Coliforms	10 to 100 ml	0	mg/l	400 organisms/100 ml (7-Day) 200 organisms/100 ml (30-Day)		NPDES Permit

Legend

m = meters
ml = milliliters
mg = milligrams
$\mu g/m^3$ = micrograms per cubic meter
$\mu Ci/ml$ = microcuries per milliliter
pCi/g = picocuries per gram
NA = Not Applicable

RF = Rocky Flats
40-CFR-61 = National Emission Standards for Hazardous Air Pollutants, Title 40, Part 61 of the Code of Federal Regulations
AECMC = AEC Manual Chapter
NPDES = National Pollutant Discharge Elimination System

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TABLE 4. Environmental Analysis Laboratory Measurement Control Data for 1975

Element	Matrix	Relative Error[a] (%)	Bias[a] (%)	Total Control Analyses
Americium	Effluent Filters (Gelman AE®)	48.5	8.2	240
Beryllium	Effluent Filters (Gelman AE®)	40.8	0.1	240
Beryllium	Effluent Filters (Whatman®)	17.3	– 10.9	240
Uranium	Effluent Filters (Gelman AE®)	35.4	2.8	240
Plutonium	Effluent Filters (Gelman AE®)	16.6	7.0	240
Americium	Surface Water	77.2	18.5	48
Uranium	Surface Water	143.2	158.3	48
Plutonium	Surface Water	30.4	– 12.4	48
Tritium	Surface Water	5.7	– 4.7	48
Strontium	Surface Water	19.2	– 7.9	48

a. Six months moving average.

TABLE 5. Effluent Releases to the Atmosphere During 1975

Sample Period	Plutonium Facilities			Uranium and Research Facilities		
	Number of Samples Taken	$C_{maximum}$[a] ($\times 10^{-12}$ μCi/ml)	Total[a] (μCi)	Number of Samples Taken	$C_{maximum}$[b] ($\times 10^{-12}$ μCi/ml)	Total[b] (μCi)
January	95	0.017	<1.507	165	0.884	< 8.545
February	100	0.013	<0.856	141	0.072	< 3.977
March	130	0.013	<0.569	144	0.057	< 3.502
April	104	0.014	<1.130	153	0.157	< 3.686
May	104	0.009	<1.094	155	0.037	< 3.001
June	130	0.004	<0.733	144	0.052	< 2.548
July	103	0.003	<0.461	144	0.118	< 4.579
August	129	0.010	<0.894	164	0.094	< 4.460
September	100	0.010	<0.566	141	0.064	< 3.220
October	101	0.027	<0.701	156	0.309	< 5.194
November	122	0.019	<0.913	143	0.048	< 2.781
December	100	0.003	<0.426	155	0.036	< 2.097
Summary	1318	0.027	<9.850	1805	0.884	<47.590

Sample Period	Tritium			Beryllium[c]		
	Number of Samples Taken	$C_{maximum}$ ($\times 10^{-12}$ μCi/ml)	Total (Ci)	Number of Samples Taken	$C_{maximum}$ (μg/m³)	Total (g)
January	152	3819	<0.162	163	0.011	<0.386
February	147	2917	<0.104	160	0.014	<0.624
March	157	8403	<0.088	167	0.021	<0.404
April	152	14700	<0.164	191	0.013	<0.306
May	152	2590	<0.168	163	0.040	<0.696
June	158	1702	<0.076	176	0.010	<0.203
July	159	1640	<0.070	180	0.017	<0.376
August	160	3350	<0.070	199	0.003	<0.176
September	141	1600	<0.058	163	0.010	<0.154
October	159	15370	<0.199	170	0.010	<0.634
November	146	8180	<0.295	163	0.013	<0.416
December	150	2500	<0.085	190	0.011	<0.806
Summary	1833	15370	<1.539	2085	0.040	<5.181

a. Radiochemically determined as plutonium.
b. Radiometrically determined as total long-lived alpha activity.
c. The U. S. Environmental Protection Agency discharge limitation for beryllium is 10 grams per day.

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TABLE 6. Plutonium in Rocky Flats Ambient Air

Station	Number of Samples Taken	Less Than Detectable	Volume (cubic meters)	Concentration[a] ($\times 10^{-15}$ µCi/ml)		Percent of RCG_a[c]
				$C_{maximum}$	$C_{average}$[b]	
S-1	12	0	445,995.0	0.407	0.053 ± 83%	0.09
S-2	12	0	443,123.0	1.227	0.176 ± 70%	0.29
S-3	12	0	458,004.0	0.324	0.048 ± 81%	0.08
S-4	12	0	473,929.0	0.486	0.104 ± 74%	0.17
S-5	10	0	313,027.0	0.263	0.099 ± 81%	0.17
S-6	11	0	464,571.0	6.335	0.972 ± 74%	1.62
S-7	12	0	466,286.0	2.676	0.565 ± 67%	0.94
S-8	10	0	376,517.0	1.111	0.461 ± 78%	0.77
S-9	12	0	486,066.0	1.801	0.488 ± 66%	0.81
S-10	5	1	141,464.0	0.292	<0.016 ±297%	<0.03
S-11	4	0	134,638.0	0.019	0.013 ±193%	0.02
S-12	11	1	484,917.0	0.147	<0.042 ± 72%	<0.07
S-13	4	1	140,601.0	0.018	<0.009 ±195%	<0.02
S-14	4	1	144,066.0	0.058	<0.015 ±222%	<0.03
S-15	4	0	121,274.0	0.059	0.032 ±199%	0.05
S-16	10	1	148,200.0	1.374	<0.064 ±159%	<0.11
S-17	11	0	462,250.0	0.139	0.053 ± 71%	0.09
S-18	9	0	150,793.0	2.112	0.124 ±172%	0.21
S-19	9	0	179,173.0	0.497	0.050 ±160%	0.08
S-20	12	0	405,438.0	1.606	0.085 ± 97%	0.14
S-21	4	0	154,863.0	0.047	0.030 ±185%	0.05
S-22	12	1	533,708.0	0.127	<0.039 ± 68%	<0.07
S-23	4	0	134,780.0	0.056	0.017 ±212%	0.03
S-24	11	0	335,182.0	0.362	0.064 ± 79%	0.11
Summary	217	6	7,598,865.0	6.335	–	–
Volume-Weighted Average					<0.198 ± 39%	<0.33

a. Monthly composite station concentrations.
b. Volume-weighted average.
c. The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air accessible to incidentally exposed individuals is 60×10^{-15} microcuries per milliliter.

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TABLE 7. Total Long-Lived Beta Activity in Rocky Flats Ambient Air--December 1975

Station	Number of Samples Taken	Less Than Detectable	Volume (cubic meters)	Concentration ($\times 10^{-12}$ μCi/ml)	Percent of RCG_a[a]
S-1	1	0	49,492	0.0377	0.04
S-2	1	0	38,603	0.0500	0.05
S-3	1	0	51,711	0.0386	0.04
S-4	1	0	40,768	0.0347	0.03
S-5	1	0	53,817	0.0430	0.04
S-6	1	0	45,011	0.0329	0.03
S-7	1	0	41,674	0.0494	0.05
S-8	1	0	40,501	0.0381	0.04
S-9	1	0	52,525	0.0478	0.05
S-10	1	0	38,614	0.0433	0.04
S-11	1	0	51,202	0.0364	0.04
S-12	1	0	52,466	0.0392	0.04
S-13	1	0	43,366	0.0341	0.03
S-14	1	0	41,345	0.0342	0.03
S-15	1	0	44,033	0.0336	0.03
S-16	1	0	38,938	0.0364	0.03
S-17	1	0	43,305	0.0446	0.04
S-18	1	0	37,335	0.0483	0.05
S-19	1	0	42,205	0.0320	0.03
S-20	1	0	46,626	0.0386	0.04
S-21	1	0	38,312	0.0370	0.04
S-22	1	0	41,957	0.0399	0.04
S-23	1	0	47,283	0.0585	0.06
S-24	1	0	40,747	0.0458	0.05
Summary	24	0	1,061,836	–	–
Volume-Weighted Average				0.0406 ±7%	0.04

a. The Radioactivity Concentration Guide (RCG_a) for total long-lived beta activity in ambient air accessible to incidentally exposed individuals is 100×10^{-12} microcuries per milliliter.

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TABLE 8. Plutonium in Three- to Six-Kilometer- (2- to 4-Miles-) Distant Ambient Air

Station	Number of Samples Taken	Less Than Detectable	Volume (cubic meters)	Concentration ($\times 10^{-15}$ µCi/ml)		Percent of RCG_a[b]
				$C_{maximum}$	$C_{average}$[a]	
S-31	12	1	461,547.0	0.144	<0.032 ± 96%	<0.16
S-32	12	1	543,346.0	0.134	<0.035 ± 96%	<0.18
S-33	12	1	531,886.0	0.097	<0.034 ± 95%	<0.17
S-34	3	1	118,243.0	0.176	<0.037 ±550%	<0.19
S-35	3	0	119,322.0	0.116	0.027 ±538%	0.14
S-36	2	0	57,286.0	0.012	0.012 ±1734%	0.06
S-37	12	0	525,181.0	0.198	0.056 ± 93%	0.28
S-38	10	0	460,089.0	0.097	0.027 ±108%	0.14
S-39	12	1	502,129.0	0.102	<0.026 ± 97%	<0.13
S-40	12	0	486,876.0	0.198	0.054 ± 92%	0.27
S-41	12	1	472,698.0	0.136	<0.033 ± 99%	<0.17
S-42	12	1	416,244.0	0.137	<0.037 ± 96%	<0.19
S-43	11	1	360,818.0	0.185	<0.056 ±105%	<0.28
S-44	12	1	429,709.0	0.094	<0.029 ±103%	<0.15
Summary	137	9	5,485,374.0	0.198	-	
Volume-Weighted Average					<0.037 ± 29%	<0.19

a. Volume-weighted average.
b. The Radioactivity Concentration Guide (RCG_a) for soluble plutonium in ambient air accessible to the population at large is 20×10^{-15} microcuries per milliliter.

TABLE 9. Plutonium in Community Ambient Air

Community	Station	Number of Samples Taken	Less Than Detectable	Volume (cubic meters)	Concentration ($\times 10^{-15}$ µCi/ml)		Percent of RCG_a[b]
					$C_{maximum}$	$C_{average}$[a]	
Boulder	S-54	12	1	447,025.0	0.108	<0.029 ±250%	<0.15
Broomfield	S-56	12	2	407,641.0	0.120	<0.031 ±214%	<0.16
Denver	S-61	11	0	256,078.0	0.117	0.019 ±540%	0.10
Golden	S-62	12	1	378,744.0	0.119	<0.041 ±226%	<0.21
Lafayette	S-55	11	1	416,609.0	0.099	<0.032 ±227%	<0.16
Leyden	S-59	10	0	311,361.0	0.069	0.039 ±233%	0.20
Marshall	S-51	11	2	406,472.0	0.138	<0.034 ±217%	<0.17
Superior	S-53	12	2	483,851.0	0.129	<0.036 ±210%	<0.18
Wagner	S-58	12	1	411,205.0	0.116	<0.035 ±212%	<0.18
Walnut Creek	S-57	9	1	382,318.0	0.077	<0.025 ±221%	<0.13
Westminster	S-60	11	0	269,922.0	0.149	0.015 ±590%	0.08
Summary	--	123	11	4,171,226.0	0.149	--	
Volume-Weighted Average						<0.031 ± 20%	<0.16

a. Volume-weighted average.
b. The Radioactivity Concentration Guide (RCG_a) for plutonium in ambient air accessible to the population at large is 20×10^{-15} microcuries per milliliter.

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TABLE 10. Total Long-Lived Beta Activity in Community Ambient Air - December 1975

Location	Number of Samples Taken	Less Than Detectable	Volume (cubic meters)	Concentration ($\times 10^{-12}$ µCi/ml)	Percent of RCG_a[a]
Marshall	1	0	45,634	0.0228	0.02
Superior	1	0	43,093	0.0172	0.02
Boulder	1	0	41,273	0.0218	0.02
Lafayette	1	0	41,129	0.0153	0.02
Broomfield	1	0	40,960	0.0319	0.03
Walnut Creek	1	0	43,644	0.0297	0.03
Wagner	1	0	39,677	0.0123	0.01
Leyden	1	0	38,629	0.0333	0.03
Westminster	1	0	38,045	0.0271	0.03
Denver	1	0	21,360	0.0199	0.02
Golden	1	0	39,591	0.0276	0.03
Summary	11	0	429,975		
Volume-Weighted Average				0.0237 ± 18%	0.02

a. The Radioactivity Concentration Guide (RCG_a) for total long-lived beta activity in ambient air accessible to incidentally exposed individuals is 100×10^{-12} microcuries per milliliter.

TABLE 11. Average Concentrations of Chemical and Biological Constituents of Liquid Effluents

Parameter	Average Concentration	Average Quantity	Applicable Standard	Agency[a]	Percent of Standard
Discharge Point 001:[b]					
pH	7.0	NA[c]	6.0 to 9.0	USEPA	In Range
Fecal Coliform Count	0/100 ml	NA	200/100 ml	USEPA	In Range
Dissolved Oxygen	6.5 mg/l	NA	4 mg/l	USEPA	In Range
Residual Chlorine	0.1 mg/l	NA	0.1 mg/l	USEPA	In Range
Suspended Solids	3.5 mg/l	2.11 kg/day	15 mg/l	USEPA	23
Biochemical Oxygen Demand, 5-Day	8.3 mg/l	5.03 kg/day	10 mg/l	USEPA	83
Phosphorus as P	1.1 mg/l	NA	8 mg/l	USEPA	33
Nitrate as N[d]	8.1 mg/l	5.22 kg/day	10 mg/l	USEPA	81
Total Nitrogen[d]	12.1 mg/l	6.40 kg/day	20 mg/l	USEPA	61
Fluoride	0.3 mg/l	NA	1.7 mg/l	USEPA	18
Total Chromium	< 0.05 mg/l	NA	0.05 mg/l	USEPA	In Range
Oil and Grease	0.3 mg/l	NA	10.0 mg/l	USEPA	3
Turbidity	0.9 JTU[e]	NA	30 JTU	CDH	In Range
Color	>10 <20	NA	50 Units	CDH	In Range
Discharge Point 002:[b]					
pH	7.9 mg/l	NA	6.0 to 9.0	USEPA	In Range
Nitrate as N	2.7 mg/l	NA	10 mg/l	USEPA	27
Discharge Point 003:[b]					
Nitrate as N	0.8 mg/l	NA	NA	USEPA	NA
Total Dissolved Solids	141.1 mg/l	NA	NA	USEPA	NA
pH	8.1 mg/l	NA	NA	USEPA	NA
Chemical Oxygen Demand	13.3 mg/l	NA	NA	USEPA	NA

a. CDH – Colorado Department of Health, Water Pollution Control Commission, Denver, Colorado
USEPA – U. S. Environmental Protection Agency, Washington, D. C. (Region Office VIII, Denver, Colorado).
b. The USEPA-NPDES discharge permit defines Discharge Points 001, 002, and 003 as the Sewage Treatment Plant, Pond A-3, and Pond C-1, respectively.
c. NA – Not Applicable.
d. January-August: Nitrate reported only as N; September-December: Total nitrogen reported.
e. JTU – Jackson Turbidity Unit.

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TABLE 12. NPDES Discharge Permit Violations

Date	Parameter	Effluent	NPDES Permit Limit	Probable Cause
January 2	BOD_5[a]	44 mg/l	25 mg/l	Denitrification of the sanitary effluent by bacterial action was attempted by purposely adding methanol upstream from the filters. It was expected that the bacteria would utilize nitrates as an oxygen source and methanol as a carbon source. The experiment was not successful and was terminated January 10.
January 3	BOD_5	260 mg/l	25 mg/l	
January 4	BOD_5	68 mg/l	25 mg/l	
January 5	BOD_5	46 mg/l	25 mg/l	
January 6	BOD_5	44 mg/l	25 mg/l	
January 9	BOD_5	52 mg/l	25 mg/l	
January 31	BOD_5	26 mg/l	25 mg/l	No abnormal operating conditions were found. Cause remained unknown.
March 31	Visible Foam	Visible Foam	None	A foaming agent used by the Fire Department accidentally entered the surface water collection system.
December 4	pH	5.9	6.9	Low influent flow and a chlorine bottle change is believed to have caused this condition.

a. Biochemical Oxygen Demand, 5-Day.

TABLE 13. Plutonium, Uranium, and Americium in Rocky Flats Ponds

Location	Number of Samples Taken	Plutonium Concentration ($\times 10^{-9}$ µCi/ml) $C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[b]
Pond A-3	9	0.090	0.550	<0.285 ±41%	<0.02
Pond B-4	48	0.559	4.457	2.635 ± 8%	0.16
Pond C-1	48	0.018	3.232	<0.235 ±68%	<0.01
		Uranium Concentration ($\times 10^{-9}$ µCi/ml)			
		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[c]
Pond A-3	6	0.681	13.302	8.685 ±48%	0.09
Pond B-4	39	1.357	9.867	2.400 ± 1%	0.02
Pond C-1	45	0.272	2.900	1.438 ±18%	0.01
		Americium Concentration ($\times 10^{-9}$ µCi/ml)			
		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[d]
Pond A-3	9	0.090	1.214	<0.254 ±97%	<0.02
Pond B-4	49	0.206	1.320	0.920 ±15%	0.07
Pond C-1	48	0.010	0.630	<0.051 ±53%	<0.01

a. Volume-weighted average.
b. The Radioactivity Concentration Guide (RCG_w) for soluble plutonium in water is $1,667 \times 10^{-9}$ microcuries per milliliter.
c. The Radioactivity Concentration Guide (RCG_w) for soluble uranium is $10,000 \times 10^{-9}$ microcuries per milliliter.
d. The Radioactivity Concentration Guide (RCG_w) for soluble americium is $1,330 \times 10^{-9}$ microcuries per milliliter.

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TABLE 14. Plutonium, Uranium, and Americium in Walnut Creek

Location	Number of Samples	Plutonium Concentration ($\times 10^{-9}$ µCi/ml) $C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[b]
Walnut Creek at Indiana Street	47	0.073	2.150	0.648 ±23%	0.04
		Uranium Concentration ($\times 10^{-9}$ µCi/ml)			
		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[c]
Walnut Creek at Indiana Street	42	0.057	5.356	2.844 ±13%	0.03
		Americium Concentration ($\times 10^{-9}$ µCi/ml)			
		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[d]
Walnut Creek at Indiana Street	49	0.018	0.930	0.181 ±30%	0.01

a. Sample-weighted average.
b. The Radioactivity Concentration Guide (RCG_w) for soluble plutonium in water is 1,667 $\times 10^{-9}$ microcuries per milliliter.
c. The Radioactivity Concentration Guide (RCG_w) for soluble uranium is 10,000 $\times 10^{-9}$ microcuries per milliliter.
d. The Radioactivity Concentration Guide (RCG_w) for soluble americium is 1,330 $\times 10^{-9}$ microcuries per milliliter.

TABLE 15. Tritium in Water Samples

Location	Number of Samples	Tritium Concentrations ($\times 10^{-6}$ µCi/ml) $C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[b]
Pond A-3	19	<0.500	2.400	<1.057 ±24	<0.11
Pond B-4	250	<0.500	3.970	<1.151 ± 6	<0.12
Pond C-1	250	<0.500	3.130	<0.837 ± 8	<0.08
Walnut Creek at Indiana Street	250	<0.500	3.514	<1.428 ± 5	<0.14
Great Western Reservoir	50	0.833	6.338	2.300 ±14	0.23
Standley Lake	50	<0.500	8.400	<1.001 ±33	<0.10

a. Sample-weighted average.
b. The Radioactivity Concentration Guide (RCG_w) for tritium in water released to uncontrolled areas is 1,000 $\times 10^{-6}$ microcuries per milliliter.

TABLE 16. Concentration of Radioactive Materials in Groundwater—May and October Analysis Results ($\times 10^{-9}$ μCi/ml)

Location Number	Depth (feet)	Plutonium		Uranium		Americium		Tritium	
		May	October	May	October	May	October	May	October
1-60	23	<0.09	LR[a]	28.86	16.08	<0.09	<0.05	2,050	1,178
2-60	30	<0.09	LR	52.89	8.76	<0.09	0.10	5,198	3,271
3-60	30	<0.09	0.36	8.40	12.49	<0.09	<0.05	5,927	8,858
4-60	30	<0.09	0.21	48.69	14.61	<0.09	<0.05	6,673	20,256
5-60	30	0.10	Dry	11.36	Dry	<0.09	Dry	1,660	Dry
6-60	30	<0.09	0.07	3.51	4.66	<0.09	<0.05	10,264	7,830
1-66	148	<0.09	0.08	1.06	0.20	<0.09	<0.05	L[b]	< 500
2-66	146	0.14	1.04	0.59	0.47	<0.09	<0.05	5,985	1,663
3-66	153	<0.09	<0.05	1.73	LR	<0.09	<0.05	L	899
1-71	30	0.09	0.13	0.38	4.35	<0.09	0.14	< 500	703
2-71	30	0.14	<0.05	0.50	0.19	<0.09	<0.05	491	< 500
3-71	25	<0.09	LR	4.60	1.58	<0.09	<0.05	781	586
4-71	22	0.09	0.08	2.48	1.06	<0.09	<0.05	< 500	1,161
5-71	28	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
6-71	30	<0.09	0.25	41.24	0.25	<0.09	<0.05	1,964	1,955
1-74	24	Dry	<0.05	Dry	LR	Dry	<0.05	Dry	703
2-74	10	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
3-74	24	Dry	0.20	Dry	2.92	Dry	<0.05	Dry	< 500
4-74	6	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
5-74	18	Dry	0.42	Dry	3.23	Dry	0.20	Dry	1,736
6-74	7	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
7-74	50	<0.09	<0.05	3.26	< 0.05	<0.09	<0.05	< 500	< 500
8-74	40	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
9-74	19	<0.09	LR	156.23	LR	<0.09	<0.05	983	616
10-74	10	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
11-74	20	<0.09	<0.05	9.20	2.98	<0.09	<0.05	880	L
12-74	4	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
13-74	19	<0.09	<0.05	12.01	LR	<0.09	<0.05	1,373	L
14-74	4	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
15-74	19	<0.09	<0.05	51.02	38.82	<0.09	<0.05	785	< 500
16-74	4	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
17-74	16	<0.09	<0.05	49.30	13.64	Lost	<0.05	2,948	2,498
18-74	7	<0.09	0.06	18.12	26.64	<0.09	0.35	< 500	1,355
21-74	265	NS[c]	0.10	NS	1.77	NS	<0.05	NS	< 500
22-74	315	NS	0.07	NS	4.96	NS	0.09	NS	< 500

a. LR means Low Recovery
b. L means lost in laboratory
c. NS means not sampled

TABLE 17. Plutonium, Uranium, and Americium in Public Water Supplies

Reservoirs	Number of Samples Taken	Plutonium Concentration ($\times 10^{-9}$ µCi/ml) $C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_W[b]
Great Western	36	<0.013	0.952	<0.099 ± 58%	<0.01
Standley Lake	36	<0.013	0.142	<0.036 ± 23%	<0.01
Summary	72	<0.013	0.952	–	
Finished Water					
Arvada	11	<0.005	0.019	<0.006 ± 50%	<0.001
Boulder	12	<0.005	0.014	<0.007 ± 17%	<0.001
Broomfield	39	<0.013	0.133	<0.041 ± 26%	<0.002
Denver	11	<0.005	0.016	<0.008 ± 29%	<0.001
Golden	11	<0.005	0.048	<0.009 ± 107%	<0.001
Lafayette	12	<0.005	0.030	<0.007 ± 67%	<0.001
Louisville	11	<0.005	0.012	<0.006 ± 21%	<0.001
Thornton	12	<0.005	0.018	<0.009 ± 32%	<0.001
Westminster	36	<0.013	0.210	<0.041 ± 31%	<0.002
Summary	155	<0.005	0.210	–	
Average	–	–	–	<0.027 ± 49%	<0.002
		Uranium Concentration ($\times 10^{-9}$ µCi/ml)			
Reservoirs		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_W[c]
Great Western	35	0.212	7.077	1.983 ± 25%	0.02
Standley Lake	30	0.668	12.005	2.746 ± 29%	0.03
Summary	65	0.212	12.005	–	
Finished Water					
Arvada	9	0.257	6.138	2.041 ± 74%	0.02
Boulder	11	0.014	0.257	0.079 ± 54%	0.01
Broomfield	31	0.382	7.515	1.468 ± 35%	0.01
Denver	10	1.058	5.193	2.537 ± 41%	0.03
Golden	8	0.054	3.028	1.250 ± 77%	0.01
Lafayette	10	0.168	0.960	0.506 ± 36%	0.01
Louisville	9	0.140	0.699	0.373 ± 34%	0.01
Thornton	9	<0.005	7.050	2.492 ± 72%	<0.02
Westminster	33	0.448	6.491	1.694 ± 31%	0.02
Summary	130	<0.005	7.515	–	
Average	–	–	–	1.437 ± 18%	<0.02
		Americium Concentration ($\times 10^{-9}$ µCi/ml)			
Reservoirs		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_W[d]
Great Western	38	0.014	< 0.090	<0.033 ± 20%	<0.01
Standley Lake	37	<0.013	< 0.090	<0.027 ± 19%	<0.01
Summary	75	<0.013	< 0.090	–	
Finished Water					
Arvada	11	<0.001	0.239	<0.026 ± 180%	<0.002
Boulder	11	<0.001	0.015	<0.006 ± 180%	<0.005
Broomfield	37	<0.023	0.150	<0.029 ± 31%	<0.003
Denver	11	<0.001	0.420	<0.043 ± 196%	<0.004
Golden	11	<0.001	0.044	<0.009 ± 80%	<0.001
Lafayette	12	<0.001	0.030	<0.007 ± 67%	<0.001
Louisville	12	<0.001	0.400	<0.039 ± 185%	<0.003
Thornton	12	<0.001	0.007	<0.005 ± 3%	<0.001
Westminster	39	<0.013	0.079	<0.029 ± 18%	<0.003
Summary	156	<0.001	0.420	–	
Average	–	–	–	<0.032 ± 25%	<0.003

a. Sample-weighted average.
b. TheRadioactivity Concentration Guide (RCG_W) for soluble plutonium in water is 1.667 × 10^{-9} microcuries per milliliter.
c. The Radioactivity Concentration Guide (RCG_W) for soluble uranium is 10,000 × 10^{-9} microcuries per milliliter.
d. The Radioactivity Concentration Guide (RCG_W) for soluble americium is 1,330 × 10^{-9} microcuries per milliliter.

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TABLE 18. Plutonium, Uranium, and Americium in Regional Lakes, Reservoirs, and Streams

Distance from Rocky Flats Plant	Number of Samples Taken	Plutonium Concentration ($\times 10^{-9}$ μCi/ml) $C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[b]
Less than 5 miles	11	<0.045	0.239	<0.071 ± 55%	<0.01
Greater than 5 miles	14	<0.045	1.471	<0.155 ±140%	<0.01
		Uranium Concentration ($\times 10^{-9}$ μCi/ml)			
		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[c]
Less than 5 miles	11	0.227	10.144	2.021 ±101%	0.02
Greater than 5 miles	16	0.059	8.309	2.680 ± 48%	0.03
		Americium Concentration ($\times 10^{-9}$ μCi/ml)			
		$C_{minimum}$	$C_{maximum}$	$C_{average}$[a]	Percent of RCG_w[d]
Less than 5 miles	11	<0.045	<0.045	<0.045 ± 0%	<0.01
Greater than 5 miles	16	<0.045	0.119	<0.050 ± 18%	<0.01

a. Sample-weighted average.
b. The Radioactivity Concentration Guide (RCG_w) for soluble plutonium in water is 1,667 × 10^{-9} microcuries per milliliter.
c. The Radioactivity Concentration Guide (RCG_w) for soluble uranium is 10,000 × 10^{-9} microcuries per milliliter.
d. The Radioactivity Concentration Guide (RCG_w) for soluble americium is 1,330 × 10^{-9} microcuries per milliliter.

TABLE 19. Radioactivity Concentrations Used for 1975 Dose Calculations

Location	Parameter	Average Concentration (μCi/ml)	Percent of RCG_a or RCG_w
Fence Line			
Air Sampler S-37	Plutonium in Air	0.056 ±93% × 10^{-15}	0.28
Walnut Creek at Indiana Street	Plutonium in Water	0.648 ±23% × 10^{-9}	0.04
Walnut Creek at Indiana Street	Uranium in Water	2.844 ±13% × 10^{-9}	0.03
Walnut Creek at Indiana Street	Americium in Water	0.181 ±30% × 10^{-9}	0.01
Walnut Creek at Indiana Street	Tritium in Water	<1.428 ± 5% × 10^{-6}	<0.14
Community			
Broomfield Air Sampler S-56	Plutonium in Air	<0.031 ±214% × 10^{-15}	<0.16
Broomfield Finished Water	Plutonium in Water	<0.041 ± 26% × 10^{-9}	<0.003
Broomfield Finished Water	Uranium in Water	1.468 ± 35% × 10^{-9}	0.01
Broomfield Finished Water	Americium in Water	<0.029 ± 31% × 10^{-9}	<0.003
Great Western Reservoir	Tritium in Water	2.300 ± 14% × 10^{-6}	0.23
80 Kilometer			
Community Average	Plutonium in Air	<0.031 ± 20% × 10^{-15}	<0.16
Community Average	Plutonium in Water	<0.027 ± 49% × 10^{-9}	<0.002
Community Average	Uranium in Water	1.437 ± 18% × 10^{-9}	<0.02
Community Average	Americium in Water	<0.032 ± 25% × 10^{-9}	<0.003

TABLE 20. Factors for Conversion from Concentration to Dose[a] (rem-ml/μCi-yr)

Organ	Air Factor	Water Factors			
	Plutonium	Plutonium	Uranium	Americium	Tritium
Total Body	2.57×10^{10}	3.40×10^{2}	3.58×10^{2}	1.21×10^{3}	1.01×10^{2}
Bone	1.05×10^{12}	1.38×10^{4}	3.66×10^{3}	1.49×10^{4}	NA[b]
Liver	1.61×10^{11}	2.00×10^{3}	NA	1.69×10^{4}	NA
Kidney	1.20×10^{11}	1.58×10^{3}	1.50×10^{3}	8.49×10^{3}	NA
Pulmonary Region	2.38×10^{12}	NA	NA	NA	NA

a. Concentrations expressed in μCi/ml multiplied by these conversion factors gives dose in rem/year.
b. NA means not applicable.

ILLUSTRATIONS

Figures 1 through 8

FIGURE 1. Location of the Rocky Flats Plant and Surrounding Communities

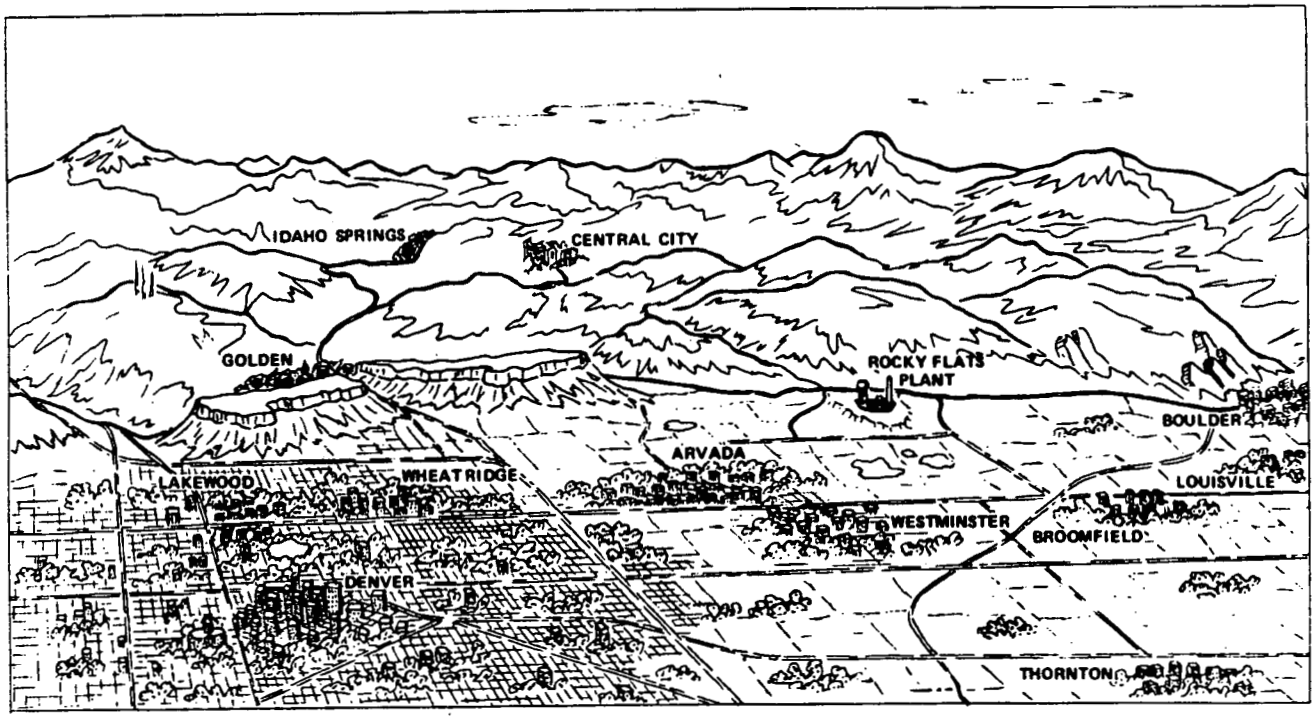

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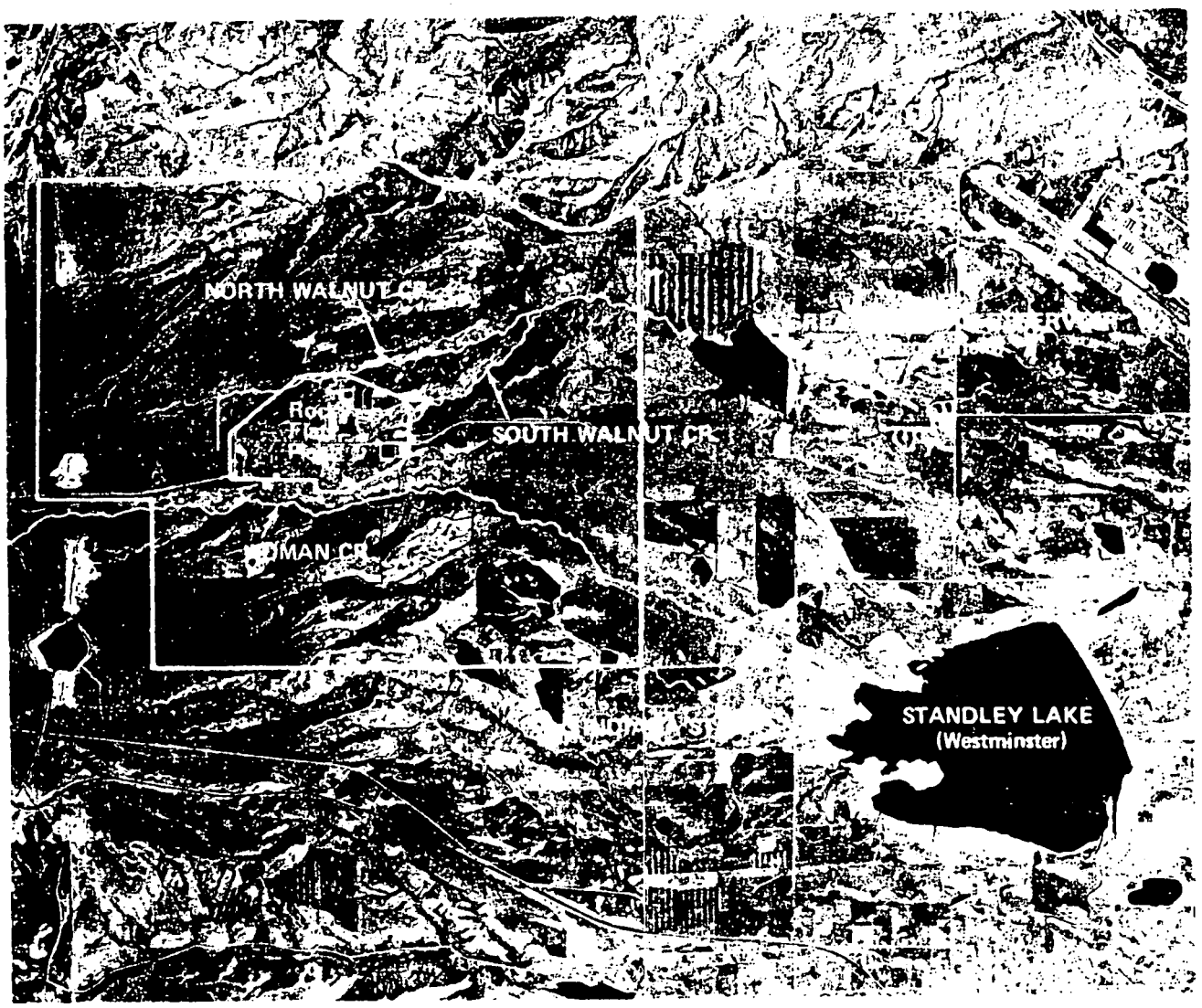
FIGURE 2. Location of the Rocky Flats Plant Boundaries

15299



360

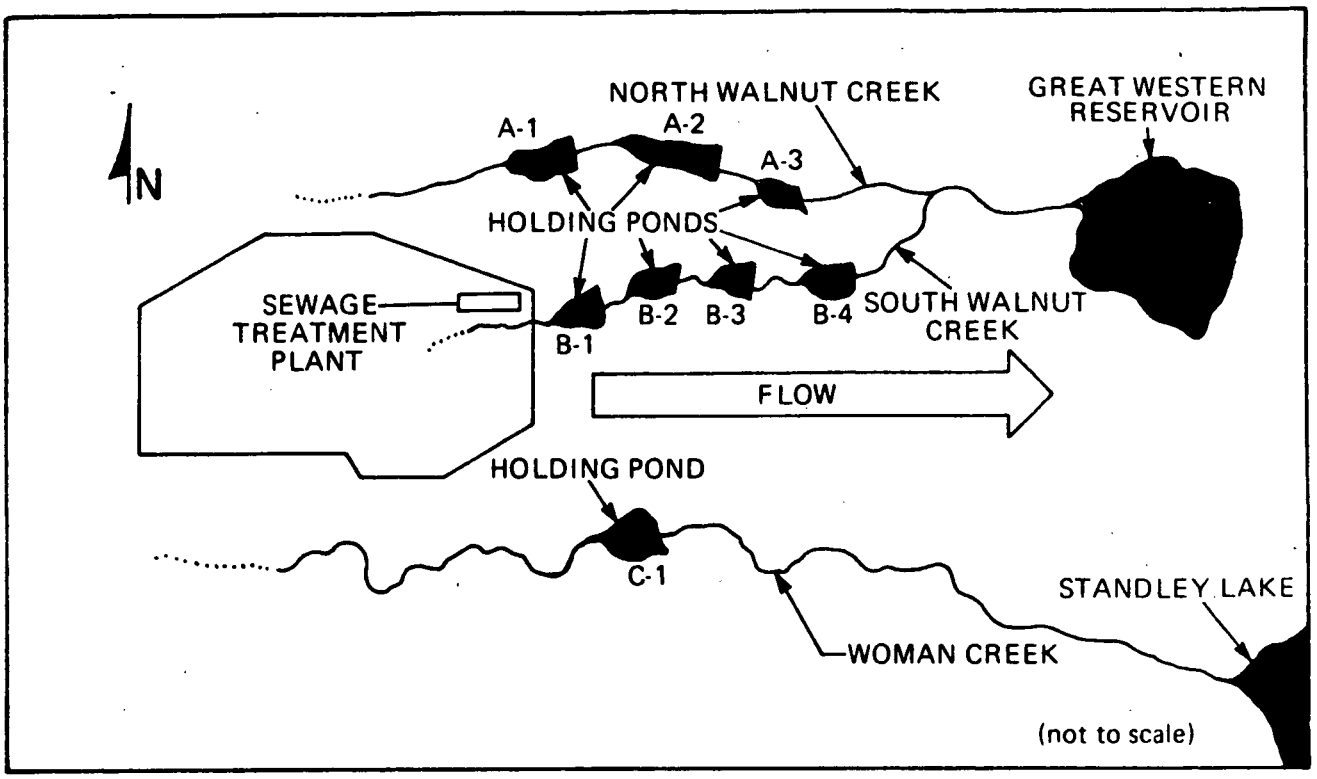


FIGURE 3. Liquid Effluent Watercourses

FIGURE 4. The 1975 Wind Rose

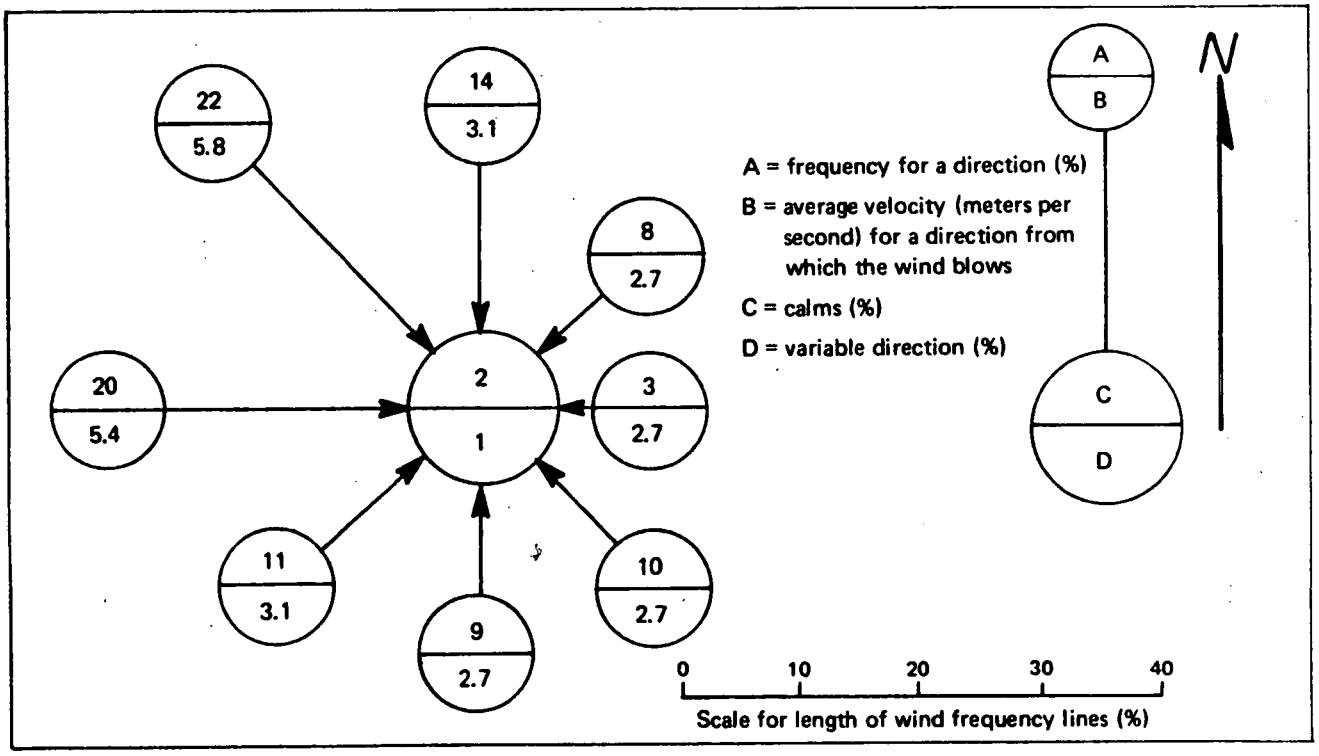


FIGURE 5. Location of On-Site Ambient Air Samplers

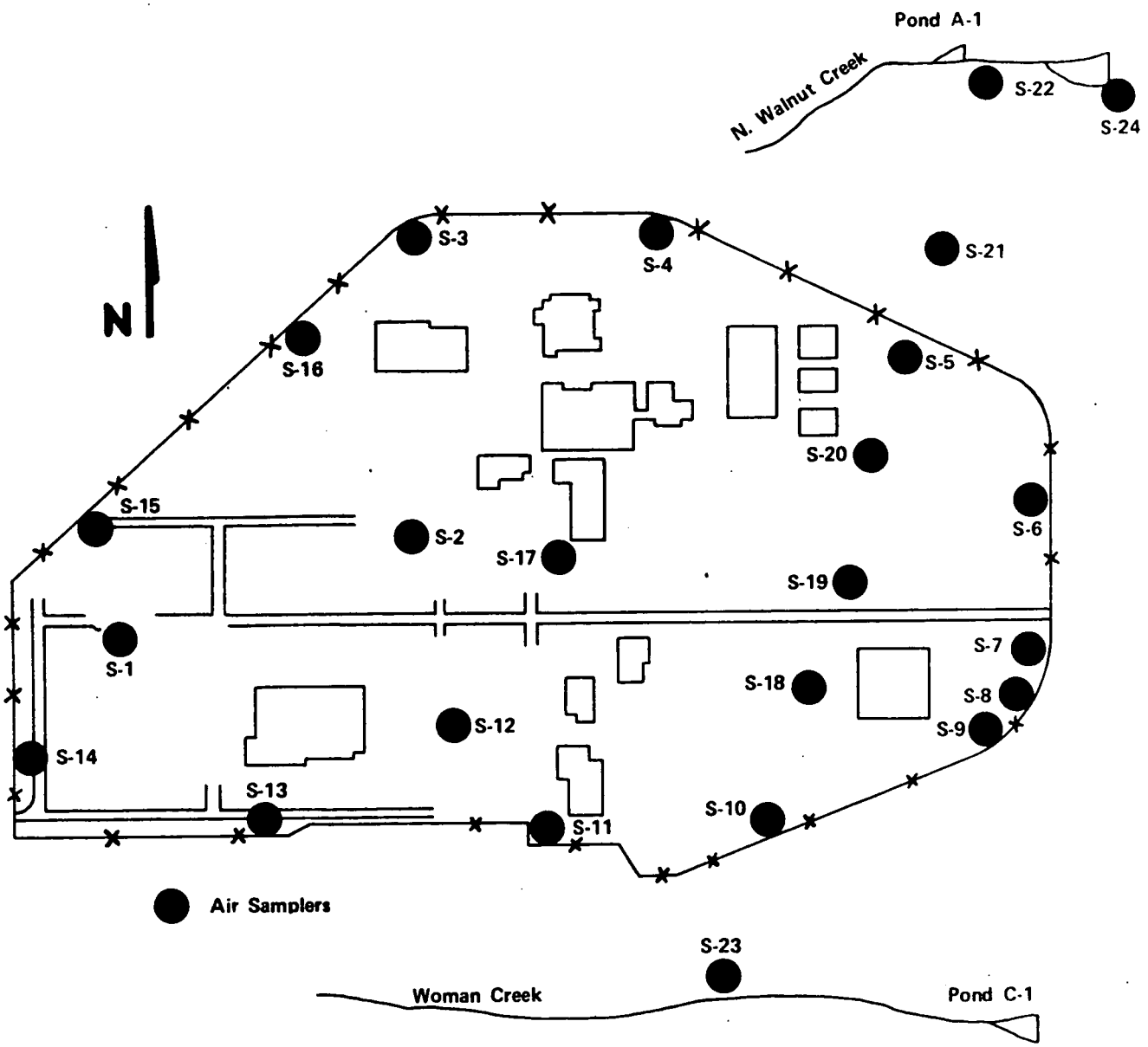
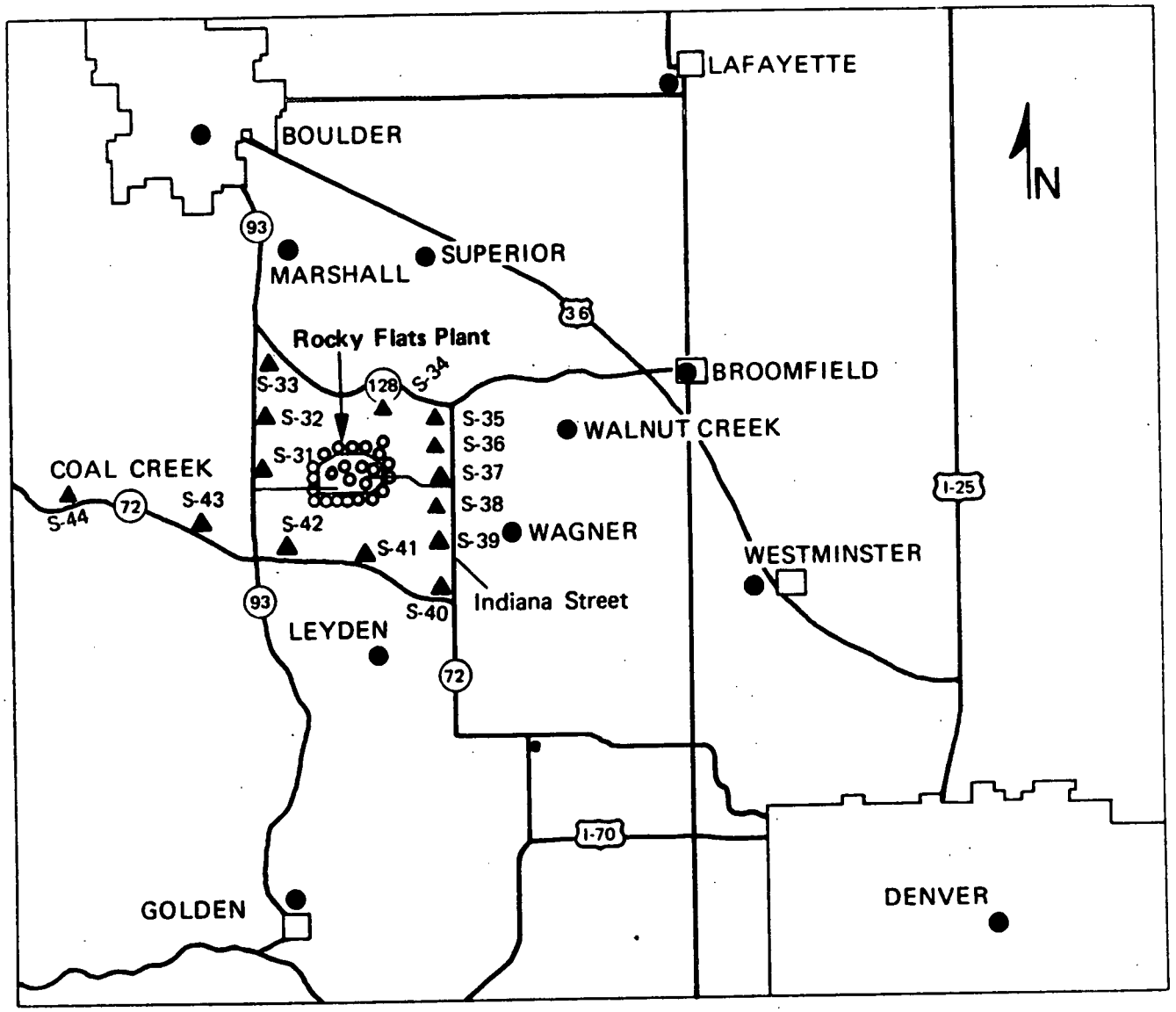


FIGURE 6. Location of Off-Site Ambient Air Samplers



Legend

o – On-Site Air Samplers.

▲ – Air Samplers, 3 to 6 kilometers (2 to 4 miles) distance.

● – Community Air Samplers.

FIGURE 7. Location of Hydrologic Test Holes

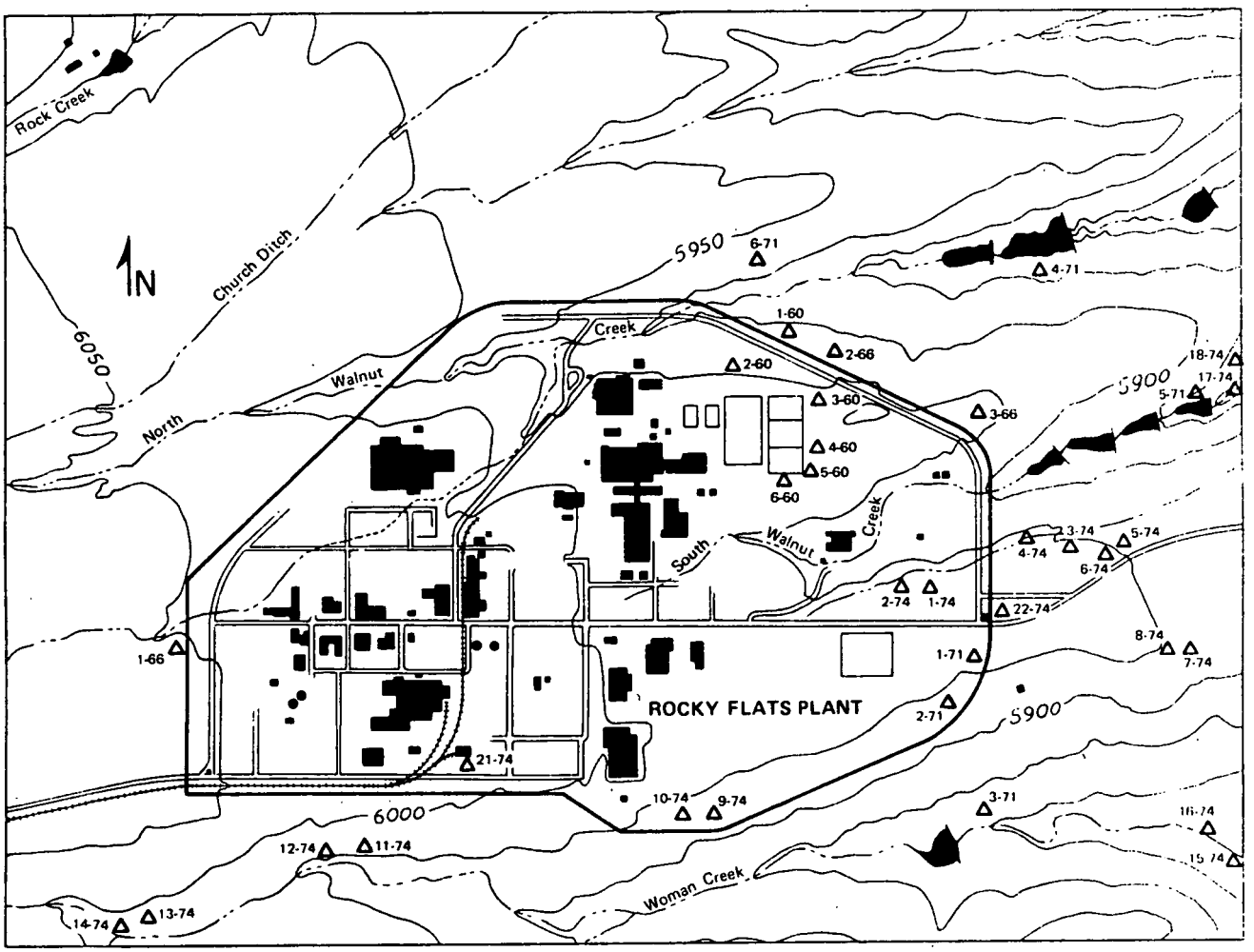
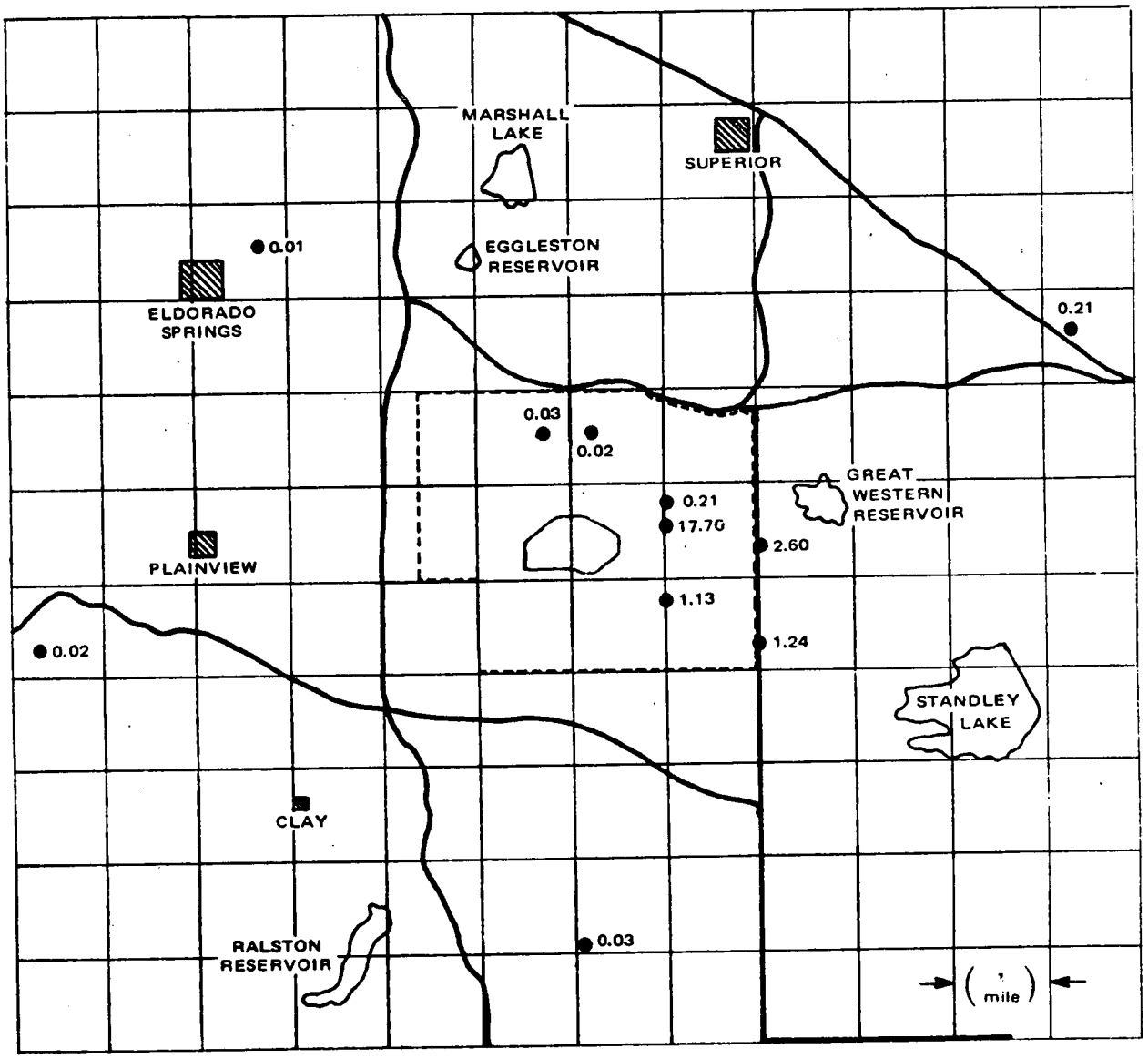


FIGURE 8. Plutonium Concentrations in Soil. (Values in picocuries per gram.)



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